TEMS™ CellPlanner

GSM Technical Reference Manual

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Preface

Document Conventions

This document uses the following conventions:

Bold type	Window names, button names, and keyboard keys are displayed as bold text. Example: Click **Edit.**
Menu↗Selection	Navigation in menu paths are displayed as bold text with arrows between menu levels.
`Typewriter type`	File names and literal input and output. Example: `sites.xml`
Italic type	Book titles and definitions are displayed in italic. Examples: *carrier mapping, Technical Reference Manual*
Left-click Right-click	All instructions including mouse clicks assume a mouse configured with the left mouse button as primary button.

Navigation

Use the ALT ← and ALT → buttons to navigate between link jumps in the Manuals.

Assumed Knowledge

This documentation presumes that you have good knowledge about radio network planning principles and the radio technology to plan.

Disclaimer

The parameter values in this manual are just examples to help you getting started quickly, and do not constitute any performance guarantees for the planned equipment of your final network planning.

Proper parameter values depend on the equipment version, the operator's business plan, and the operator's network deployment strategy. Recommended parameter values should be provided by the operator, the equipment vendor or your service delivery organization.

Manuals

The following PDF manuals are delivered with the TEMS CellPlanner software:

Installation Guide

EN/LZT 108 9831 R4A

Describes system requirements, how to install and configure TEMS CellPlanner components and manage licenses, and provides an overview of all TEMS CellPlanner components. The procedures must be performed by a user with administrator privileges on the local computer. Some procedures require that you are an authorized TEMS CellPlanner administrator.

Common Features User's Guide

EN/LZT 108 9832 R4A

Includes Glossary of terms used in TEMS CellPlanner, concepts about licenses, and how use projects, explorer objects used by more than one radio technology, how to add sites and use site tools, filters, plots, neighbors, AMI, tuning propagation models, ASMT (Automatic Sector Model Tuning), puncturing, export and import data, and work with projects on server. Here TEMS CellPlanner administrators find how to administer users, groups and projects on servers shared by multiple users.

Common Features Technical Reference Manual

EN/LZT 108 9833 R4A

Describes radio technology independent algorithms, parameters and file formats.

GeoData User's Guide

EN/LZT 108 9834 R4A

Describes geodata concepts, supported geodata formats, conversion between different map formats, how to use map data tools in TEMS CellPlanner. The chapters about providing and importing map data are intended for administrators of map data. Other chapters are intended for users of map data.

Map Import Wizard User's Guide

EN/LZT 108 9943 R2A

Describes how to import map data using a generic wizard similar to the one provided with TEMS LinkPlanner. The intended reader is administrator of map data.

LTE User's Guide

EN/LZT 108 9944 R3A

Describes how to use LTE functions of TEMS CellPlanner, including analysis, and creation of plots and reports.

LTE Technical Reference Manual

EN/LZT 138 0235 R2A

Describes LTE network planning principles, analysis details for advanced users, and cell ID planning principles.

WCDMA User's Guide

EN/LZT 108 9837 R4A

How to use WCDMA functions of TEMS CellPlanner, including analysis, and creation of plots and reports.

WCDMA Technical Reference Manual

EN/LZT 108 9838 R4A

Describes concepts and overviews of WCDMA algorithms, and HSPA and MBMS in TEMS CellPlanner.

GSM User's Guide

EN/LZT 108 9835 R4A

Describes how to use the GSM functions of TEMS CellPlanner, including analysis, and creation of plots and reports.

GSM Technical Reference Manual

EN/LZT 108 9836 R4A

Describes overlaid/underlaid cell structures, reuse patterns, manual frequency planning, automatic frequency planning (AFP), automatic hopping frequency set (HFS) planning, optimization of BSIC, HSN and MAIO, fractional load planning, and effective subscriber modeling. Also describes the GSM algorithms and file formats used in TEMS CellPlanner.

WiMAX User's Guide

EN/LZT 108 9839 R4A

Describes how to use the WiMAX functions of TEMS CellPlanner, including analysis, and creation of plots and reports.

1
Overview of TEMS CellPlanner

This chapter provides an overview of the TEMS CellPlanner product.

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About TEMS CellPlanner

TEMS™ CellPlanner is a graphical PC-based application for designing, implementing, and optimizing mobile radio networks. It assists you in performing complex tasks, including network dimensioning, traffic planning, site configuration, frequency planning, and network optimization.

Installation

The Installation Guide describes how to install software and licenses.

Product Packaging

The product package includes the software components listed below.

What is actually installed depends on your selection in the installation wizard.

Product Components	Selecting this component installs...
• TEMS CellPlanner *named "TEMS CellPlanner Client" in the manuals*	• Radio Technology Features • Planning Features • Manuals • Map tools, geodata conversion software, demo maps, filters, scripts • Citrix software - relevant only if you are going to offer this TEMS CellPlanner installation as a Citrix service
• Enterprise Server	Enterprise Server software plus the User Administration software
• Zero Admin Server	Zero Admin Server software plus the User Administration software
• User Administration	User Administration software only
• License Server	License Server software only

Some of the components are licensed, see Licensed Components on page 1-3.

The Installation Guide provides an overview of each component and how the components relate to each other.

Licenses

The Installation Guide describes how to install licenses.
The Common Features User's Guide describes how to activate licensed features.

Licensed Components

Three of the Product Components are licensed:

TEMS CellPlanner *named "TEMS CellPlanner Client" in the manuals*	To start TEMS CellPlanner you need a license for at least one of the Radio Technology Features. Additional licenses are required for each of the Radio Technology Features and Planning Features to use.
Enterprise Server	License required to start the server
Zero Admin Server	License required to start the server

Radio Technology Features

Each of the radio technology software modules listed below require an installed and activated license. How to use the radio technology software is described in adherent user guides and technical reference manuals.

- GSM
- WCDMA
- WCDMA,HSPA
- WiMAX
- LTE

Planning Features

Additional planning features can be used together with the radio technology software. These additional software modules require a license for the feature itself and a license for the adherent radio technology:

• Automatic Cell Planning	Requires WCDMA or WCDMA,HSPA license
• Automatic Frequency Planning	Requires GSM license. This license is required also for automatic HFS planning.
• Automatic Measurement Integration and ASMT	Requires license for at least one of the Radio Technology Features ASMT = Automatic Sector Model Tuning.

Support and FAQ

For support and FAQ about TEMS CellPlanner, use the TEMS support web site:

www.ascom.com/networktesting

To provide TEMS support with information when reporting a problem, follow the instructions in chapter *Support Information* in the Installation Guide.

2
Advanced GSM Planning

This chapter describes the theory and principles beyond the advanced GSM planning features of TEMS CellPlanner.

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2.1 Frequency Planning Principles

The performance of a network is optimized by careful planning of the individual frequencies in every cell, aiming to minimize the interference.

In this chapter you will learn the principles beyond the frequency planning functions provided by TEMS CellPlanner.

2.1.1 Terminology in Frequency Planning

We start with some fundamental definitions used in frequency planning.

separation requirement

A separation requirement is the minimum required frequency distance between cells. Separation requirements can be regulatory, for instance to avoid interference between operators on the same GSM band, or defined to minimize interference within a network. Urban environments normally require higher separation than sub-urban or rural environments.

A separation requirement of x Hz between cell A and cell B means that if cell A uses frequency F, then cell B may use frequencies <= F-x or >= F+x.

In TEMS CellPlanner, separation requirements are configured in Separation Specifications.

re-use distance

The re-use distance is the minimum distance between cells using the same frequency. The re-use distance D is calculated as D = R * SQRT(3*N), where R is the cell radius and N is the number of cells per cluster. A re-use distance is necessary to avoid co-channel interference.

fixed frequency

Fixed frequency planning is the opposite of frequency hopping. A connection uses the same frequency during the entire call.

frequency hopping

A frequency hopping connection changes frequency from one time slot to another to reduce the impact from interference. The hopping rate in GSM networks is slow frequency hopping (SFH).

There are two fundamental types of frequency hopping: baseband hopping where few frequencies are used, and synthesizer hopping which can utilize the entire spectrum.

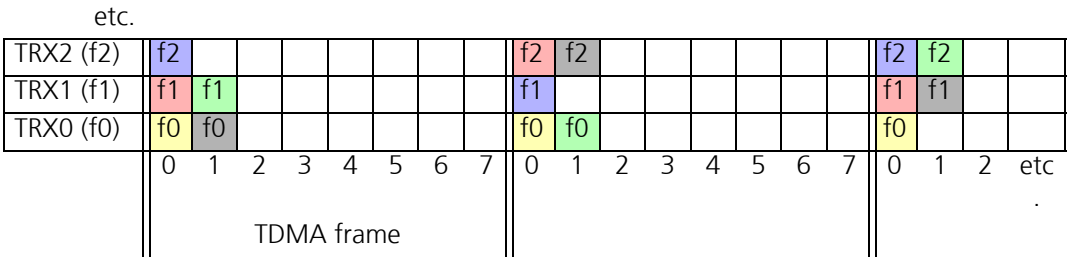
Frequency hopping is normally applied to TCH TRXs, but if BCCH is configured as hopping, the hopping TCH channels may also use the frequency assigned to the BCCH TRX in time slots when BCCH is inactive.

baseband hopping

With baseband hopping, or baseband frequency hopping, each TRX is assigned one frequency. A connection is frequency hopping by alternating between TRXs on a frame-by-frame basis. Each connection may thus use several TRXs (one per frame).

As there is a one-to-one relation between TRX and frequency, a large number of TRXs are required to use many frequencies.

The example below illustrates five calls, where each call has its own color:



synthesizer hopping

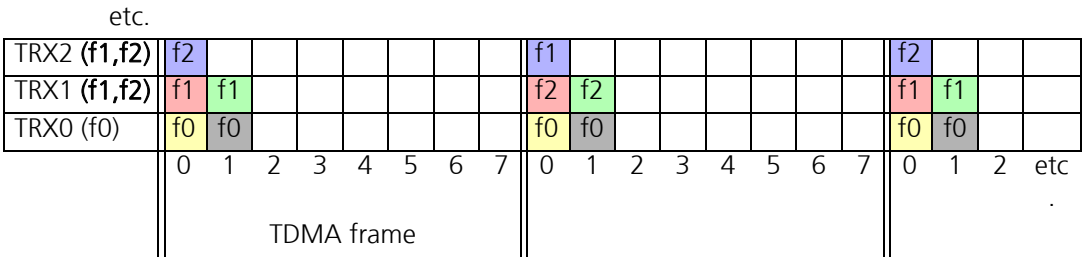
With synthesizer hopping, or synthesized frequency hopping or simply "synth hopping", the TRXs may use multiple frequencies. The entire frequency spectrum can be used with a smaller number of TRXs compared to what is needed for baseband hopping.

Frequency hopping is achieved by synchronizing the frequency for each TDMA frame. A connection does not change TRX, instead its TRX is tuned to use new frequencies between each frame.

The synthesizer hopping can be either staggered or blocking.

The ratio of TRXs that hop to the number of hopping frequencies is called the *fractional load*, see Fractional Load Planning (FLP) on page 2-29.

The example below illustrates five calls, where each call has its own color. Note that the example is extremely simplified. In a real case there should be many more frequencies than TRXs, to achieve a fractional load of at least 50%.



frequency re-use pattern

For planning with frequency groups, cells are arranged in a regular hexagonal pattern. This is a simplified model of real networks, to plan for frequency re-use based on a regular pattern. Most networks are planned with three-sector sites, so the number of frequency groups is usually a multiple of 3.

A set of frequency groups must be created, in which each group contains one or no BCCH frequency, and a number of TCH frequencies.

The re-use pattern is designated as X/Y, where

X = number of sites
Y = the *re-use factor*, also the number of frequency groups, and number of columns in a frequency group set

See Examples on Frequency Re-Use Patterns on page 2-4.

re-use factor

See frequency re-use pattern.

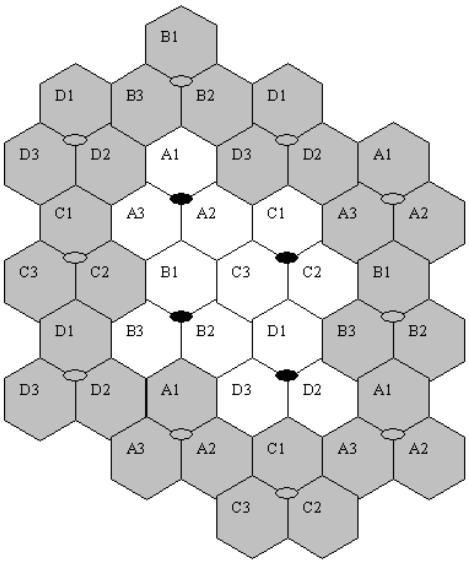
2.1.2 Examples on Frequency Re-Use Patterns

Frequency groups are used to plan fixed and baseband hopping and frequencies. The BCCH and TCH frequencies may be included in the same frequency groups.

Example with 4/12 Re-Use

Figure 2–1 illustrates a 4/12 re-use pattern with 12 frequency groups assigned to 4 three-sector sites. The frequency groups are designated as A1, A2, A3, B1, … D3, where the letter identifies the site (indicated by a small ellipse) and the digit identifies the cell (sector) within that site.

Figure 2–1 Frequency re-use pattern 4/12



4/12 re-use means that 4 sites are assigned 12 consecutive channels, and the pattern is repeated. Each site has 3 sectors (cells), and each sector gets 1/12 of all channels.

In this example, the BCCHs use ARFCN 1 to 12. BCCHs as well as TCH frequencies are planned according to a 4/12 re-use pattern. The set of BCCH and TCH frequency groups in Table 2-1 is created.

Table 2-1 Frequency group set for 4/12 frequency re-use

TRX	Group	A1	B1	C1	D1	A2	B2	C2	D2	A3	B3	C3	D3
#1	BCCH	1	2	3	4	5	6	7	8	9	10	11	12
#2	TCH 1	13	14	15	16	17	18	19	20	21	22	23	24
#3	TCH 2	25	26	27	28	29	30	31	32	33	34	35	36
#4	TCH 3	37	38	39	40	41	42	43	44	45	46	47	48

The groups are arranged so that adjacent frequencies are not assigned to two cells in the same site.

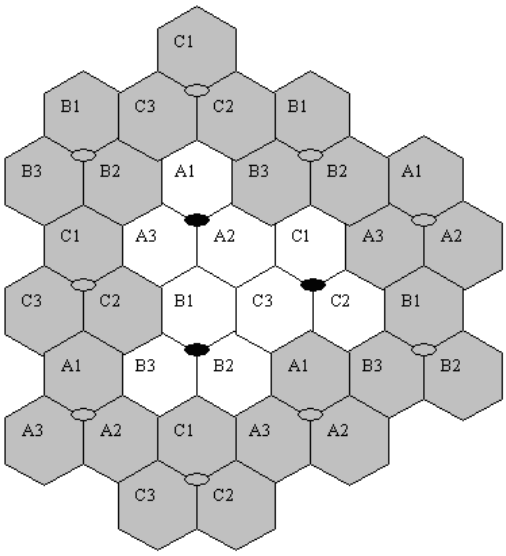
Example with 4/12 BCCH and 3/9 TCH Re-Use

In this example, the BCCHs use ARFCN 1 to 12 and are planned according to a 4/12 re-use pattern. However, the TCH frequencies are planned according to a 3/9 re-use pattern. The set of TCH frequency groups in Table 2-2 is created.

Table 2-2 Frequency group set for 3/9 re-use

TRX	Group	A1	B1	C1	A2	B2	C2	A3	B3	C3
#2	TCH 1	13	14	15	16	17	18	19	20	21
#3	TCH 2	22	23	24	25	26	27	28	29	30
#4	TCH 3	31	32	33	34	35	36	37	38	39

Figure 2–2 Frequency re-use pattern 3/9



Example with 3/9 TCH Re-Use with Borrowed Frequencies

The BCCH frequency and the TCH frequencies can be allocated from a selected frequency group to every cell. If there are more TRXs in a cell than the number of frequencies in the frequency group, one or more TCH frequencies can be "borrowed" from another frequency group and assigned to the additional TRXs. This can be done by pure manual planning, or assigning single frequencies to single TRXs in manually optimized planning.

To avoid using a BCCH adjacent or close to one of the TCHs in the same cell, some allocations may need to be switched. BCCH and TCHs are planned separately. This results in re-use patterns that are not completely regular.

Borrowing might result in the frequency allocations below for twelve cells with different number of TRXs, where BCCH is already planned using its own frequency group set.

Table 2-3 3/9 TCH re-use in 12 cells

TRX	Group	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
#1	BCCH	1	2	3	4	5	6	7	8	9	10	11	12
#2	TCH 1	13	14	15	16	17	18	19	20	21	13	**32**	15
#3	TCH 2	22	23	24	25	26		28	29	30	22		24
#4	TCH 3			33	34			37		39	**31**		
#5	TCH 4			**36**									

Cell 3 is assigned all TCH frequencies in group C1 (in Table 2-2) and has "borrowed" ARFCN 36 from group C2. With a repeated pattern after 9 cells, cell #11 should use ARFCNs 14 and 23 (from group B1), but skips that and thus avoids using the same ARFCNs as cell #2.

2.1.3 Multiple Re-Use Patterns (MRP)

To ensure that a connection is made, interference must be low on BCCH. Mobiles perform measurements on BCCH frequencies, and the base station must transmit in all timeslots on the BCCH frequency with full output power. The BCCH is protected against interference only by a high re-use factor, for example 15.

Interference on TCH frequencies is decreased by downlink DTX and power control, or when the traffic load is low, leaving some channels unused. TCH frequencies can be planned with lower re-use factors, such as 12 or 9.

Even tighter re-use is accomplished by introducing Overlaid/Underlaid Cell Structures.*Multiple re-use patterns (MRP)* are created by dividing the TCH frequencies into two or more layers, used exclusively in the underlaid or overlaid subcells. For example, TCHs in underlaid subcells planned with a 4/12 re-use pattern, and overlaid subcells planned with a 3/9 re-use pattern.

When all cells do not have the same number of TRXs, the last TRXs in cells with many TRXs can be planned with even tighter re-use. The interference on the TRXs is limited since only the few number of cells with many TRXs use the same frequency group set.

Example of Multiple Re-Use Patterns

The following tables show how ARFCNs 1 to 60 are grouped in four frequency group sets with different reuse factor, used for BCCH and TCH planning with MRP, and in this case also with overlaid/underlaid subcells.

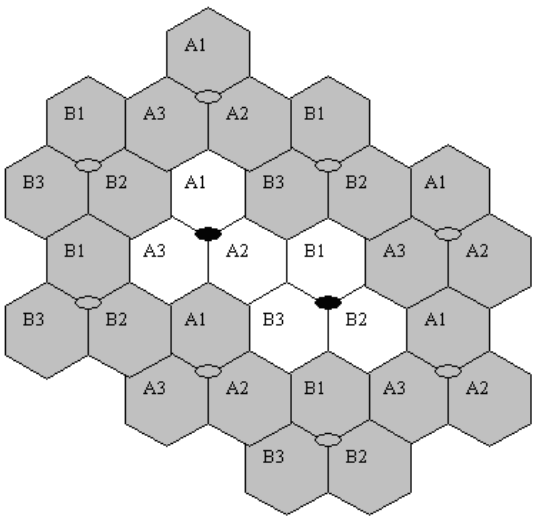
Table 2-4 Multiple re-use patterns

TRX	Group	Reuse	A1	B1	C1	D1	E1	A2	B2	C2	D2	E2	A3	B3	C3	D3	E3
#1	BCCH	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
#2	Underlaid TCH 1 and TCH 2	12	16	17	18	19	-	20	21	22	23	-	24	25	26	27	-
#3			28	29	30	31		32	33	34	35		36	37	38	39	
#4	Overlaid TCH 1	9	40	41	42	-	-	43	44	45	-	-	46	47	48	-	-
#5	Overlaid TCH 2 and TCH 3	6	49	50	-	-	-	51	52	-	-	-	53	54	-	-	-
#6			55	56				57	58				59	60			

The first TRX in every cell carries the BCCH and uses an ARFCN between 1 and 15. There are 15 BCCH frequency groups, which means that the re-use is 15. The next two TRXs carry TCHs in the underlaid subcells and are planned with ARFCNs 16 to 39 divided into 12 groups, that is, they have re-use 12. The fourth TRX is allocated in the overlaid subcell and is planned with ARFCNs 40 to 48 and re-use 9. If TRX numbers five and six are present, they are planned with ARFCNs 49 to 60 and re-use 6.

Example of 2/6 Re-Use Pattern

The cells with a second and third overlaid TCH in Table 2-4 are planned with a 2/6 re-use pattern as shown in the illustration below. If adjacent or close frequencies are used in the same cell, some frequencies or frequency groups must be switched, possibly resulting in a somewhat irregular re-use pattern.



Tight re-use causes severe interference when all cells are used simultaneously. A multiple re-use pattern works well only if the frequency layer with tightest re-use is used by only a fraction of all cells, see Fractional Load Planning (FLP) on page 2-29.

2.2 Frequency Planning in TEMS CellPlanner

There are four ways to plan frequencies with TEMS CellPlanner, summarized in the table below.

Type of planning	Hopping types		
	fixed frequency	baseband hopping	synthesizer hopping
Pure Manual Frequency Planning	X	X	X
Manually Optimized Frequency Planning	X	X	
AFP for Fixed Frequency or Baseband Hopping	X	X	
AFP for Synth Hopping			X

Whatever type of planning you choose, you must perform some Preparations for Frequency Planning.

Preparations for Frequency Planning

Before you can plan frequencies with TEMS CellPlanner, you must do the following:

- Assign the required number of channel groups to each cell. If your network plan includes Overlaid/Underlaid Cell Structures, you must assign channel groups to the overlaid sub-cells as well.
- Assign the required number of TRXs to each channel group. You can assign the TRXs manually or by results from the traffic analysis. There is one BCCH frequency per cell. TEMS CellPlanner always maps the BCCH to the first TRX in Channel group 0. You must assign the desired BCCH frequency to this TRX, and the TCH frequencies to the other TRXs.
- Declare each channel group as fixed frequency, baseband hopping or synthesizer hopping.
- Plan Re-Use Patterns
- Plan for Frequency Hopping

Plan Re-Use Patterns

You configure re-use patterns in frequency group sets. The first frequency group in each set will always be named *A0*.

If you want to create three different Multiple Re-Use Patterns (MRP), for example 4/12, 3/9 and 2/6, the cells must contain three channel groups each, as TEMS CellPlanner allows only one frequency group per channel group. The three channel groups will be numbered 0, 1 and 2.

Plan for Frequency Hopping

You can assign frequency group sets (for baseband hopping) or hopping frequency sets, HFSs (for synthesizer hopping), to every channel group in every cell. One HSN per synthesizer hopping channel group, and one MAIO per TRX, shall be assigned.

2.3 Overlaid/Underlaid Cell Structures

Traffic capacity in a GSM network can be increased by adding new frequencies or by reducing the frequency re-use distance.

When no more frequencies may be added, a second frequency pattern with tighter frequency re-use can be laid on existing cells. The *overlaid subcells (OL)* have shorter range than the original cells, in this context termed *underlaid subcells (UL)*, to decrease the risk for excessive co-channel or adjacent channel interference. The overlaid subcells are introduced throughout the network to obtain a system-wide capacity increase.

Due to the smaller size of the overlaid subcells, a tighter frequency re-use pattern can be applied to the overlaid subcells compared to underlaid subcells. For example, 3/9 re-use can be applied to overlaid subcells and 4/12 re-use to underlaid subcells. In this way, the number of available frequencies per cell is increased, and thus the system capacity increases.

The traffic in a cell can be directed to the overlaid subcell when the mobile is close to the site, and to the underlaid subcell when being close to the cell border. Mobile stations within the overlaid subcell service area are served by the overlaid subcell. Only if the overlaid subcell is fully used, mobile stations within its service area are served by the underlaid subcell.

Overlaid subcells are often planned as frequency hopping, while underlaid subcells (with BCCH) are planned as non-hopping, as complete coverage is prioritized for the underlaid subcell while increased capacity is desired in the overlaid subcell. Typically a re-use pattern like 4/12 can be used in the non-hopping layer, while tighter re-use patterns like 3/9, 1/3, and 1/1, are more suitable for the hopping layer.

TEMS CellPlanner supports overlay with one additional layer, which may but must not use another frequency band than the underlaid cell. Do to this limitation, this manual uses the term *dual-band* cell as a synonym to the generic *multi-band* cell.

Overlaid/Underlaid Cell Structure versus HCS

OL/UL cell structures are easily mixed up with Hierarchical Cell Structures (HCS), see HCS Bands and HCS Layers on page 3-3. The main differences are as follows:

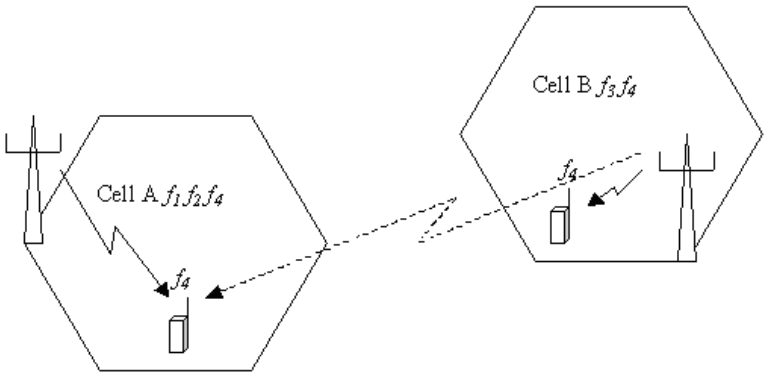
- HCS layers are normally used for capacity increase in hotspot zones, while an OL/UL cell structure is normally implemented in large parts of the network to increase the capacity in the entire network.
- HCS hotspot cells normally have shorter range than OL subcells.
- RRM (radio resource management) criteria for load balancing is different. Overload traffic is moved between HCS layers according to priority, but between OL/UL subcells according to distance from the site.
- OL subcells normally require higher Tx power than HCS hotspots, due to the difference in range.

Example of Overlaid/Underlaid Cell Structure

Consider two cells located near to each other; cell *A* containing frequencies *f1* and *f2* and cell *B* containing frequencies *f3* and *f4*.

The traffic intensity in cell *A* is high. It is decided to assign *f4* also to cell *A* to solve the capacity problem. Due to the close proximity of cells *A* and *B*, this creates interference problems for mobiles close to the cell borders. The solid arrows in Figure 2–1 indicate the carrier signals in cells *A* and *B*, and the dotted arrow indicates a downlink interfering signal from cell *B*.

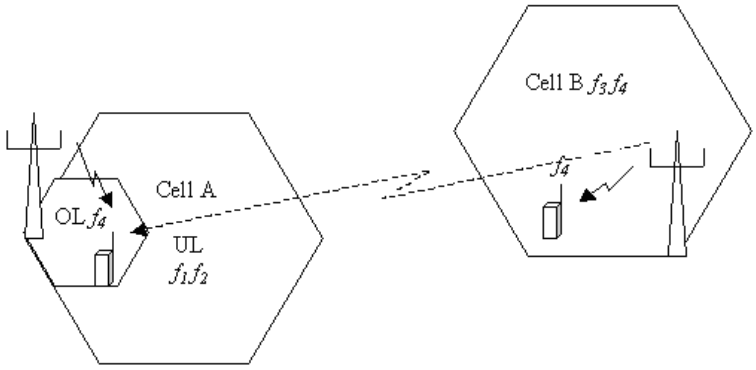
Figure 2–1 Before applying overlaid/underlaid subcell structure



The interference problem is solved by applying an overlaid/underlaid subcell structure in cell *A*. The frequency *f4* is assigned to the overlaid subcell, and *f1* and *f2* to the underlaid subcell. The size of the overlaid subcell is limited by a threshold for the allowed pathloss.

The connections using *f4* in cell *A* experience less pathloss from the overlaid subcell, hence they "hear" the signal from cell *A* better compared to the one from cell *B*, resulting in an improved C/I.

Figure 2–2 After applying overlaid/underlaid subcell structure to cell A



The mobile can use *f4* in the overlaid subcell as long as the co-channel interference is relatively low. When the mobile moves closer to cell *B*, but is still in cell *A*, the C/I for *f4* is decreasing, and the mobile has to use *f1* or *f2* instead.

Parameters Determining Overlaid/Underlaid Cell Structure

The modeling of overlaid/underlaid subcells requires some dedicated parameters.

The size of the overlaid subcell is limited by two parameters:

- max pathloss threshold
- max timing advance

A mobile station may connect to the overlaid subcell when (pathloss < max pathloss threshold) AND (timing advance < max timing advance).

The *pathloss* includes the base station antenna gain and antenna radiation pattern.

The *timing advance* is equal to the round-trip delay between the cell and the mobile station, measured in bit period units of 48/13 μs = 3.6923 μs. It controls when bursts shall be transmitted from a mobile station to arrive to the cell's receiver in the correct timeslot without overlapping adjacent timeslots. Increasing the timing advance with one unit corresponds to a cell radius increment of 553 meters.

If the algorithm attempts to connect more mobile stations than allowed, according to load parameters, to the overlaid sub-cell, some of them are instead connected to the underlaid subcell as long as there is capacity.

Two other parameters can be set to specific values for the overlaid subcell:

- Tx power
- Training Sequence Code (TSC)

Due to the pathloss condition, less *Tx power* is needed to reach mobile stations in the overlaid subcell. The Tx power for the overlaid subcell is set to a lower value than that of the underlaid subcell. A lower Tx power is required to reduce the downlink interference from the overlaid subcell into the underlaid subcell.

The overlaid subcell is assigned a different *TSC* than the underlaid subcell. The TSC is used by the mobile station to distinguish between different transmissions on the same frequency. When configuring an overlaid subcell network, it is advisable to assign the TSCs for the overlaid subcells according to the overlaid subcell frequency re-use pattern. Otherwise co-channels in the overlaid subcell network might obtain the same TSC, which could make it difficult for the mobile station to distinguish between these co-channels.

The TSC of the underlaid subcell is set equal to the BCC, the BSIC part assigned to the cell. The BCCs should be planned so that the mobile station distinguishes between underlaid subcells (or ordinary cells) using the same frequency. If this planning has already been performed, it is not recommended to change the TSC of the underlaid subcell.

2.4 Pure Manual Frequency Planning

TEMS CellPlanner provides functions for automatic planning of frequencies. There are however some cases when you have to plan frequencies the hard way, by assigning frequencies to TRXs, one by one.

2.5 Manually Optimized Frequency Planning

When automatic frequency planning tools are unavailable, or when a specific frequency re-use pattern is desired, frequency group planning must be performed manually. You can do it either by tedious Pure Manual Frequency Planning, or by the manually optimized frequency planning described in this chapter.

TEMS CellPlanner supports manually optimized frequency planning for single-band or dual-band networks, and the BCCH and TCH carrier layers may overlap.

The function is not really "optimized", as there is no algorithm that automatically finds better and better solutions. It is rather a "quick" manual frequency planning, as you can use drag and drop to quickly assign frequencies to entire cell clusters or channel groups.

Example of Frequency Group Assignment

A typical example of manual frequency planning is to create a frequency plan with frequency groups for 4/12 frequency re-use pattern.

First you create the 4/12 frequency group set. The frequency groups in each frequency group set are named A0, A1, A2, B0, B1, and so on.

Secondly you assign frequency groups A0, A1 and A2 to the three cells of the first site, B0, B1 and B2 to the second site, and so on.

Example of Assigning Multiple Reuse Patterns (MRP)

To create a manual frequency plan with MRP, you might want to assign one group from each of four different frequency group sets to a certain cell. The frequency group sets are called, for example, 5/15, 4/12, 3/9 and 2/6, where the second number in each expression is the re-use factor.

You assign *5/15 A0* and *4/12 D0* to channel group 0 in the underlaid subcell of a cell, and *3/9 B0* and *2/6 A0* to channel group 1 in the overlaid subcell. If there are only two TRXs in the overlaid sub-cell, you can select the frequencies to use in the group *2/6 A0*. If you do not select frequencies, the application makes a random frequency selection.

An underlaid sub-cell may contain more TRXs than frequencies in groups *5/15 A0* and *4/12 D0*. You can assign individual frequencies to the remaining TRXs, or select another frequency group, for example 4*/12 B2*, and assign one or both frequencies from that group to the remaining TRX(s).

MRP may be combined with but does not require Overlaid/Underlaid Cell Structures.

2.5.1 Synthesizer Hopping with FLP

To perform Manually Optimized Frequency Planning with synthesizer hopping, you must decide which kind of Fractional Load Planning (FLP) to use.

Synth hopping BCCHs are planned in the same way as fixed-frequency BCCHs.

Synth hopping TCHs must belong to a hopping frequency set (HFS) and use FLP-1/1 or FLP-1/3. With FLP, each frequency is used only a fraction of the time. FLP allows tight frequency re-use since transmission is distributed over more frequencies than there are TRXs. The number of frequencies should be at least twice as many as the number of TRXs, to achieve a fractional load > 50%. The network must also use downlink DTX and power control to keep the interference level low.

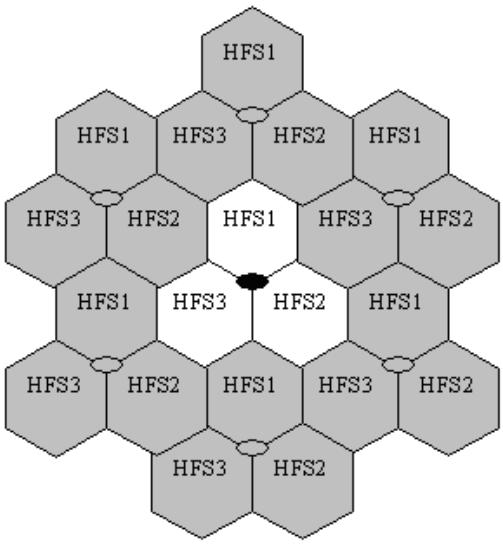
FLP-1/1

When one HFS is assigned to all cells, FLP-1/1 is applied. All hopping TCH carriers are collected in one HFS used in all cells. FLP-1/1 requires Synchronized Cells Within Site.

FLP-1/3

Each frequency is used only a fraction of the time with fractional load planning (FLP). If three different HFSs are assigned to the three cells at a site, we apply FLP-1/3. All hopping TCHs are divided into three HFSs per site, that is, one HFS per cell.

The cell pattern for FLP-1/3 is shown in the following illustration:



Synchronized Cells Within Site

To distribute the interference evenly, a pseudo-random hopping sequence number (HSN) should be assigned to the synthesizer hopping channel groups in every cell.

The hopping in the cells of a site can, but is not always required to, be synchronized by setting the RBS option **Synchronized**. With this option set, the frequencies are hopping at the same time, using the same hopping pattern.

When hopping is synchronized within a site, all cells in the site use the same HSN, and MAIO Optimization must be performed to avoid frequency collisions. A MAIO list containing one MAIO for each TRX must also be assigned to the synthesizer hopping channel group in every cell.

When hopping is not synchronized, the HSNs should be planned so that the same HSN is not re-used in two cells close to each other.

2.6 Automatic Frequency Planning (AFP)

TEMS CellPlanner provides two functions for Automatic Frequency Planning (AFP). The functions are similar but used for different purposes:

- AFP for Fixed Frequency or Baseband Hopping
- AFP for Synth Hopping

AFP assigns frequencies to BCCH and TCH layers in new or existing GSM frequency plans, taking the interference impact into account. The resulting frequency plan is optimized for minimal interference, to fulfill as many separation requirements as possible with as low interference cost as possible.

You can evaluate the results with interference plots to see if they meet your requirements. Then you can optimize the frequency plan again to get better results with lower interference cost.

AFP for Dual-Band (Multi-Band) Frequency Optimization

It is possible to plan frequencies for dual-band networks and dual-band cells, but it is necessary to run the AFP once for each frequency band.

The optimizer treats dual-band overlaid subcells as separate cells. For example, when a dual-band 900 underlaid/1800 overlaid cell is optimized, only one frequency band at a time is planned. So you must run the optimization twice, once for the 900 frequency and once for the 1800 frequency.

AFP for Co-Banded OL/UL Cell Optimization

For overlaid/underlaid cell pairs of the same frequency band, the overlaid cell is handled as part of its underlaid cell. It cannot be modeled as a separate cell during optimization. This means that the interference data for the overlaid cell is taken from its underlaid subcell in the co-banded case.

For forbidden frequencies of co-banded overlaid/underlaid cells, the set of forbidden frequencies in both cells is the union of the forbidden frequencies in the overlaid and underlaid cell.

For neighbor cells, the overlaid subcell is always considered to have the same set of neighbors as its underlaid subcell, whether or not the overlaid cell is co-banded with the underlaid cell.

Essential Input for AFP: Interference Table

Performance measurements from a live network are used as input to improve the existing frequency plan. As an example, an interference matrix created by the optimization tools FAS and FOX delivered with Ericsson's OSS-RC can be imported into TEMS CellPlanner and be converted to an interference table for use in the AFP.

2.6.1 AFP for Fixed Frequency or Baseband Hopping

Required Input

The following items are the most important input data for this function:

- Separation Specifications
- Essential Input for AFP: Interference Table

More required input is listed in the *TEMS CellPlanner GSM User's Guide*

Separation Specifications

One or more separation specifications are essential input to AFP.

A separation specification is a list of cost items. Each item specifies the separation requirements and the penalty (interference cost) of violating the requirement.

The separation specification applies to the TRXs in the selected cells. You can view the separation specifications of each TRX to see the effects of multiple filters and planning policies. You can also save and load the separation specifications to/from an XML file.

Typically you can define separation specifications for the following purposes:

- Plan BCCH layer only
- Plan TCH layer only
- Modify an existing frequency plan
- Plan the BCCH layer in a number of cells
- Plan TCH layer and retain the BCCH layer
- Plan all layers simultaneously
- Expand TCH TRXs
- Add TCH TRX frequencies to cells

A separation specifications consists of:

- Planning cells and border cells selections by filters
- Channel selection indicating the type of channel(s) to plan
- Planning policy options (Plan, Keep or Plan unallocated)
- Minimum channel spacing settings, that is, the number of channels between TRXs in the same cell, site or neighbor cell.
- Advanced options, including selections for locked channels and penalty (interference) costs

2.6.2 AFP for Synth Hopping

This function is also called "Automatic Hopping Frequency Set (HFS) Planning", "HFS Optimization" or "HFS planner". It generates an optimized hopping frequency set (HFS) for all planned GSM sites, taking the frequency settings of border sites into account. Each HFS includes a list of ARFCNs to use for synthesizer hopping.

Required Input

The following items are the most important input data for this function:

- Essential Input for AFP: Interference Table

More required input is listed in the *TEMS CellPlanner GSM User's Guide*

Principles of HFS Optimization

An interference table and the HFS size are required as input. The HFS size is the number of hopping frequencies in the hopping frequency set.

The HFS size may be configured either as a constant for all sites, or as a multiplier value. The multiplier value will be used to calculate the HFS size per site as a multiple of the maximum number of synthesizer hopping TRXs in any cell of the site.

The HFSs of all cells of a site will get the same HFS size.

The HFS planner searches for a solution that minimizes the total interference penalty cost for all planned sites. During the HFS planning, the status field displays a chart showing the progress in terms of interference penalty versus time.

The HFS planner will search for an optimal solution until stopped by the user, or when the penalty cost fulfills any of the following criteria:

1. Improved <1% during the last 50 seconds AND
   improved <1% with the last 100 candidates
2. Improved <1% with the last 1000 candidates
3. Zero cost obtained

The HFS planner takes only the interference cost into account. There is no cost or requirement on the channel separation, since the separation requirement are handled by the subsequent MAIO Optimization.

Since the same HFS is assigned to all cells of a site, the HFS planner treats every site as a unit.

Limitations on HFS Optimization

The HFS planner uses the AFP module as the optimization engine. To make this possible, there are some limitations to input and optimization:

- **Layer separation - no overlap**. The BCCH and TCH frequency layers may not overlap. A frequency used in an HFS in one cell may not be used outside an HFS in another cell, for example as BCCH or baseband hopping TCH. This restriction applies to the set of cells included in the optimization.
- **One band at a time**. AFP works with one frequency band at a time. Multiband OL/UL is supported, but the bands are optimized separately.
- **No fix-frequency TCHs**. All TCH TRXs of all cells included in the HFS planning, and belonging to the analyzed frequency band, must be synth hopping.
- **Co-sited cells must be synchronized and use the same HFS**. Separate MAIO Optimization is required to obtain the necessary frequency separation.
- **Single synth hopping channel group**. There must be exactly one synth hopping channel group in any cell included in the HFS planning. If there are separate OL and UL subcells, only one of them can have a synth hopping channel group.
- **TRX locks not retained**. The ARFCNs in the HFS are not bound to specific TRXs in the cells at the site, so TRX locks are ignored.

2.7 BSIC Optimization

The Base Station Identity Code (BSIC) is associated with and controls TRXs. It consists of a Network Color Code (NCC) and Base Station Color Code (BCC).

The terminal uses the BSIC to identify cells with the same BCCH frequency when a handover is performed. It is important to have unique BSIC and BCCH assignments for cells that are close to each other. At BSC borders the BCCH frequency can be identical in both BSCs, thus the BSIC is needed to distinguish between the cells.

It is especially important that the BCCH carriers are well planned. Otherwise there is a risk that the terminals will need a longer time to decode the BSIC, due to bad signal quality, which results in a slow handover.

With an efficient BCCH plan, the BSIC decoding is not needed more often than every 10 seconds. A longer time to decode the BSIC could cause a mobile to still report an old BSIC although being covered by another BCCH. This could cause a failed handover.

In TEMS CellPlanner, the BSIC optimization is derived from lists of neighbor cells and a list of interfering cells. If the cells in those lists have the same BCCH carriers and the same BSIC, penalty costs increase. The optimizer tries to assign a new BSIC to reduce the penalty cost, and thus increase the possibility for successful handovers. The optimizer runs through all assignments to achieve minimum possible costs.

2.8 HSN Optimization

The Optimize HSN function is used to assign hopping sequence numbers (HSN) for a GSM network plan. You can plan networks with one or more frequency bands and different carrier layers that may overlap, comprising BCCH and TCH.

The function plans only one synthesized-hopping or baseband-hopping channel group per cell.

HSN Assigned in Channel Groups

The hopping sequence number (HSN) is associated with channel groups in the GSM cell attributes. An HSN is assigned to each channel group and is a digit from 0 - 63. Zero indicates cyclic hopping, and other values indicate different pseudo-random hop sequences.

You can assign an HSN value to a frequency hopping channel group in a cell or selection of cells.

HSN Optimization

HSN optimization is derived from:

- List of all cells in each site
- List of neighbor cells
- List of interfering cells

When the channel groups specified for synthesizer or baseband hopping are assigned equal hopping frequencies, the HSN optimizer assigns different HSN numbers. However, when two or more channel groups perform synchronized synthesizer hopping, the HSN optimizer assigns the same HSN number, since frequency collisions are avoided by means of MAIO planning, in this case.

Input Required for HSN Planning

The input to HSN planning consists of cell data including site, cell and channel group configurations, neighbor relations, and an interference table. The input may also comprise pre-defined HSN assignments.

An HSN plan can be created only when an optimized frequency plan, containing HFSs (synthesizer-hopping frequency groups) or baseband-hopping channel groups, exists. For a HSN plan, the following cost function parameters are used:

- Co-site cost
- Neighbor cost
- Interference cost

Definition: HSN Assignment

An HSN assignment is defined as one HSN for one synthesizer-hopping or baseband-hopping channel group.

No cell should contain more than one synthesizer-hopping or baseband-hopping channel group. If a cell contains more than one hopping channel group, only the first hopping channel group in the cell is planned.

Every assignment contributes to the cost function of HSN planning. Changing an assignment can affect the cost of other previously made assignments. The total cost of a plan is found by adding the cost of all assignments.

HSN Cost Function

The cost of a HSN assignment is calculated from:

- The number of assignments of the same HSN and ARFCN to other synthesizer-hopping channel groups in co-sited cells that are not synchronized to the present cell.
- The number of assignments of the same HSN and ARFCN to other synthesizer-hopping or baseband-hopping channel groups in neighbor cells at other sites (not synchronized to the present cell).
- The co-channel interfered area or traffic in the present cell caused by a co-channel assignment in an interfering cell, when the same HSN and ARFCN are assigned to the synthesizer-hopping or baseband-hopping channel group in the present cell and in the interfering cell, and the two cells are not synchronized.

Calculating HSN Assignments

The HSNs available for planning the hopping channel groups are the integers 1 - 63. The value "HSN = 0", the default, is not assigned by the function, but can be entered manually.

The function considers HSN assignments outside of the planned area, without changing those assignments. The function does not change HSN assignments that have been locked.

The function tries to improve the HSN assignments that were input initially.

If a GSM RBS is synchronized, all cells of the RBS are mutually synchronized.

For every set of mutually synchronized cells, all synthesizer-hopping channel groups in the cells are synchronized.

If two or more synchronized synthesizer-hopping channel groups have equal HFS lengths (equal number of frequencies), they are assigned the same HSN. Synchronized synthesizer-hopping channel groups with different HFS lengths are assigned different HSNs.

All baseband-hopping channel groups at a site are assigned different HSNs unless they are synchronized.

The program assigns HSNs to all synthesizer-hopping or baseband-hopping channel groups, taking the restrictions into account. For every new assignment, the program tries to minimize the cost.

The cost is calculated using the cost function.

The optimization procedure stops when the program cannot find any more improvements of the HSN plan, and the HSN plan is displayed.

2.9 MAIO Optimization

When you optimize the Mobile Allocation Index Offset (MAIO), you assign and optimize MAIO for a GSM network plan.

You can optimize networks with one or more frequency bands and different carrier layers (which may overlap), comprising BCCH and TCH for GSM.

You can optimize MAIO for cells containing a synthesizer-hopping channel group and one or more fixed frequency and baseband-hopping channel groups.

Input for MAIO Optimization

MAIO optimization requires cell data including site, cell and channel group configurations. The input may also include pre-defined MAIO assignments.

You can optimize MAIO only when an optimized frequency plan exists containing HFSs (synthesizer-hopping frequency groups) and HSN allocations.

Definition: MAIO Assignment

A MAIO assignment is defined as one MAIO for one TRX in a synthesizer-hopping channel group.

Every assignment contributes to the cost function. Changing an assignment can affect the cost of other assignments made previously. The total cost of a plan is found by adding the cost of all assignments.

Definition: Synchronized Channel Groups

Two synthesizer-hopping channel groups in two different cells are mutually synchronized when the following requirements are met:

- The channel groups belong to cells in the same RBS.
- The cells are synchronized (by RBS option "Synchronized")
- The channel groups have been assigned HFSs of the same size.
- The channel groups have been assigned the same HSN.

Cost Function

The co-cell separation requirement must always be met, and when the co-site requirement is not met, a cost is generated.

The cost of a new MAIO assignment in a synthesizer-hopping channel group is based on the MAIO assignments in other synthesizer-hopping channel groups, synchronized to the present channel group.

The cost of the new MAIO assignment equals the sum of the costs of all MAIO assignments in the other channel groups, where the total is taken over all MAIO assignments in the other channel groups.

Minimum ARFCN Separation

The minimum ARFCN separation achieved for a certain pair of MAIO assignments, is derived from the HFSs assigned to the respective channel groups.

MAIO Optimization

MAIO optimization makes new MAIO assignments, or tries to improve MAIO assignments made previously.

In a synthesizer-hopping channel group that has been assigned an HFS with N carriers, the available MAIO numbers is the set of integers 0, 1, and so forth up to N-1. The number of assignments to be done is equal to the number of TRXs in the channel group.

- Checking the co-cell separation
- Planning synchronized channel groups

For every set of mutually synchronized synthesizer-hopping channel groups, the program outputs a common MAIO plan.

2.9.1 Synchronized Channel Groups Using the Same HFS

For a set of mutually synchronized cells with channel groups using the same HFS (1/1-hopping), the "first even, then odd" principle applies to the whole set of cells, so that the first MAIO number (0) is assigned to the first cell, the second MAIO number (2) is assigned to the second cell and the third MAIO number (4) is assigned to the third cell. More MAIO numbers from the "first even, then odd" list are successively assigned to each cell as required.

The function checks that the MAIO plan fulfills the co-cell separation requirement for all cells. If this is not the case, the function changes the plan so that these requirements are met. The function also tries to minimize the cost of the plan.

Example

Three synchronized channel groups have been assigned a HFS containing the ARFCNs 21, 22, 23, 24, 25, 26, 27.

The first channel group gets MAIO number 0, the second channel group gets MAIO number 2, and the third channel group gets MAIO number 4.

A second TRX in one channel group would get MAIO number 6 according to the main rule. However, in the first channel group MAIO number 6 violates the co-cell separation requirement, so another MAIO number must be assigned.

MAIO number 1 is not allowed. If the assignment of MAIO number 2 or 4 has cost 28, while MAIO number 3 has cost 12 and MAIO number 5 has cost 1, MAIO number 5 should be assigned.

2.9.2 Synchronized Channel Groups Using Staggered HFSs

When all the mutually synchronized cells have channel groups that use different HFSs (if there are three cells, this is called 1/3-hopping), then as a general rule, the "first even, then odd" principle is tried individually in each cell; the MAIO numbers 0, 2, and so forth are assigned to all three cells.

In the case of 1/3-hopping with staggered HFSs (consecutive ARFCNs are allocated one by one to the three HFSs), the "first even, then odd" principle does not succeed if the required co-site separation is 2 for all the cells. If the MAIO numbers in the second cell are increased by 1, the MAIO cost becomes zero. The co-cell separation requirement is always met.

Example

Three synchronized channel groups are assigned different, staggered HFSs:

- The first HFS contains the ARFCNs 21, 24, 27, 30
- The second HFS contains ARFCNs 22, 25, 28, 31
- The third HFS contains ARFCNs 23, 26, 29, 32

If the site separation = 2, the MAIO plan {0, 2} in all three cells has a total cost of 16.

The program tries to minimize the cost by changing the MAIO plan in one of the cells. The minimum cost, 0, is found when the second channel group is assigned the MAIO numbers {1, 3}.

2.9.3 Synchronized Channel Groups Using Blocked HFSs

In the case of 1/3-hopping with blocked HFSs (each HFS consists of consecutive ARFCNs), the "first even, then odd" principle is tried individually in each cell.

If both cell and site separation equal 2, then the co-site separation must be met for all the cells. Then MAIO numbers 0, 2, 4, … can be assigned to all the cells, and the MAIO cost becomes zero.

However, if the required separation for the cell equals 3, then the co-cell separation must be met. The function must then assign MAIO numbers 0, 3, 6, … to each of the cells, and the MAIO cost becomes zero.

2.9.4 Synchronized Channel Groups Using Other Types of HFSs

The HFSs in the synchronized channel groups may not be clearly staggered or blocked, and they may also contain some common ARFCNs. In such cases, the program performs a simple optimization of the MAIO numbers.

2.10 Fractional Load Planning (FLP)

In a GSM network, fractional load planning (FLP) improves the network capacity and quality. TEMS CellPlanner can model a GSM network using FLP.

Fractionally loaded networks, planned with extremely tight reuse (1/1 or 1/3) are a very competitive method to achieve high spectrum efficiency. This is especially true:

- For operators with smaller frequency spectrums available
- Where traditionally planned networks cannot take full advantage of the interference averaging effects of frequency hopping

The high capacity potential, together with a simplified process of frequency planning and a decreased cost for operations and maintenance have made FLP a very attractive alternative for many operators.

How Fractional Load Planning Works

FLP together with MAIO planning decreases the overall interference in the network by using each frequency a fraction of the time but with a tight frequency re-use.

Traditional frequency planning is based on a worst case where interfering frequencies are assumed to be used all the time. This is a necessary assumption when the interference hitting a fixed-frequency connection comes from one or a few interfering fixed frequency connections. The fact that the radio resources are used a fraction of the time cannot be considered.

FLP offers a simple and powerful way to achieve good quality in a network with little effort for frequency planning. As long as traffic is within certain limits, the network can grow and TRXs can be added with small operations and maintenance cost.

As FLP requires synthesizer hopping, no frequency planning considerations are required for FLP when installing an extra TRX, except that the hopping frequency set (HFS) should have enough frequencies.

Hopping Frequency Sets and Sequence Numbers

The frequency is selected from a hopping frequency set (HFS). A HFS is a list of frequencies used by the hopping TRXs in a cell. The frequency in each TDMA frame is pointed out by a Hopping Sequence. The Hopping Sequence is identified by a hopping sequence number (HSN). Since two TRXs in a cell must not use the same frequency at the same time, the TRXs are given different frequency offsets called *MAIO* values.

Each frequency is used only a fraction of the time in each cell. By planning the MAIO values together with the HFSs and HSNs, the interference in the network is minimized.

Hopping Gain

The effect of leveling out the fading and interference on different frequencies, achieved for a hopping connection, is expressed as a *hopping gain* (also called frequency diversity gain). The hopping gain increases with the number of frequencies in the HFS.

One or Two Channel Groups

Options for channel groups in a synthesizer hopping network include:

- Use one channel group with BCCH carrier-zero filling
- Use two (or more) channel groups: one channel group for BCCH and one (or more) for hopping TCHs

The BCCH frequency is used by mobile stations for signal strength measurements prior to call set-up and handover. The base station must transmit with full power on all eight timeslots on the BCCH frequency, even those not used for traffic. This transmission is called BCCH carrier-zero filling.

Option	Description
One channel group	The BCCH frequency is included in the HFS. The first timeslot, carrying the BCCH channel, is not hopping. Since the hopping TCH connections use the BCCH frequency only occasionally, the base station must be equipped with an additional transmitter to perform the BCCH carrier-zero filling.
Two channel groups	One channel group contains only the BCCH frequency, and the other channel group contains the HFS used by the hopping TCH connections. The TCH timeslots on the BCCH frequency are used for fixed-frequency connections. No additional transmitter is required for BCCH carrier-zero filling, and all timeslots on the BCCH frequency are fully used. Downlink power control is fully used on the TCH frequencies without problems, since no hopping occurs between BCCH and TCH frequencies. Intra-cell handover to the other channel group is used when a connection has poor quality.

Types of Fractional Load Planning

Types of fractional load planning include:

FLP Type	Description
FLP-1/3	All TCH frequencies are split into three groups and used within a group of three cells
FLP-1/1	All TCH frequencies are used in all cells.

Both 1/1 and 1/3 reuse are very robust, and handle networks with uneven transceiver distributions without problems and without need for adjustments. It is thus easy to add more transceivers to the network when needed. This is repeated until the average load reaches the acceptable limit.

FLP-1/3

FLP-1/3 means that all TCH frequencies are divided into three groups and used within a group of three cells, for example, a 3-sector site, with one group in each azimuth. It is recommended to hop over at least 5 frequencies in order to achieve sufficient hopping gain.

The three groups of hopping frequencies are either:

- Blocked, each group consisting of a set of consecutive ARFCNs
- Staggered, every third ARFCN assigned to each group

FLP-1/3 can be used fully without MAIO management. There is some additional adjacent channel interference between the cells within a site but it is negligible.

FLP-1/1

FLP-1/1 means that all TCH frequencies are used in all cells. FLP-1/1 gives maximum hopping gain and is especially suited for operators with narrow spectrum (less than 7 MHz).

From Ericsson's BSS R9, the number of frequencies per channel group has been increased from 16 to 32, making FLP-1/1 an optimal solution for spectrum allocations up to 9 or 10 MHz.

FLP-1/1 cannot be used fully unless the cells within a site are synchronized and using MAIO management. The same HSN should be used to achieve orthogonal frequency hopping within a site.

However, FLP-1/1 can be applied without MAIO management, using:

- Staggered BCCH/TCH frequency allocation (every second frequency is a hopping TCH)
- Different HSNs for the sectors within a site, randomly distributing the co-channel hits
- Downlink DTX and power control

This configuration has been verified in field trials and works very well. Slightly higher capacity is achieved with MAIO management. It is a good solution for operators who need more capacity but have less than 15 TCH hopping frequencies and cannot use FLP-1/3.

Hopping Sequences

The sequence of frequency use in the HFS of a hopping channel group is controlled by the Hopping Sequence Number (HSN), an integer between 0 and 63. When the HSN is set to 0, the TRXs perform cyclic hopping, that is, the ARFCNs are used successively in ascending order, starting over again from the lowest ARFCN after the highest ARFCN has been used. The other HSNs generate different pseudo-random hopping sequences.

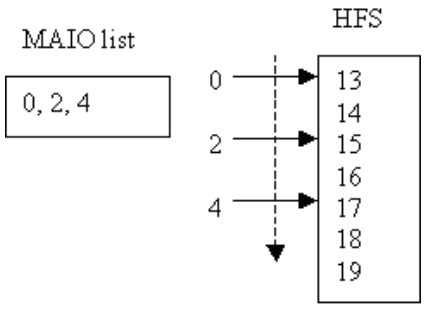
When three cells at a site perform synchronized frequency hops, they must use the same HSN. However, the sites are not mutually synchronized (possible in Ericsson's BSS R10). It is recommended to use different HSNs at neighboring sites, so interference between sites is distributed randomly over the spectrum.

MAIO Management

When a hopping channel group contains several TRXs, it is important that their frequencies do not coincide for any hop. Since they use the same hopping sequence, that is, the same HFS and HSN, the necessary frequency separation is created by a frequency offset, called a MAIO number. Each TRX in a hopping channel group must thus have a different MAIO number.

Example MAIO List

The following illustration shows an example of a MAIO list used in a cell with a HFS with blocked frequency allocations.



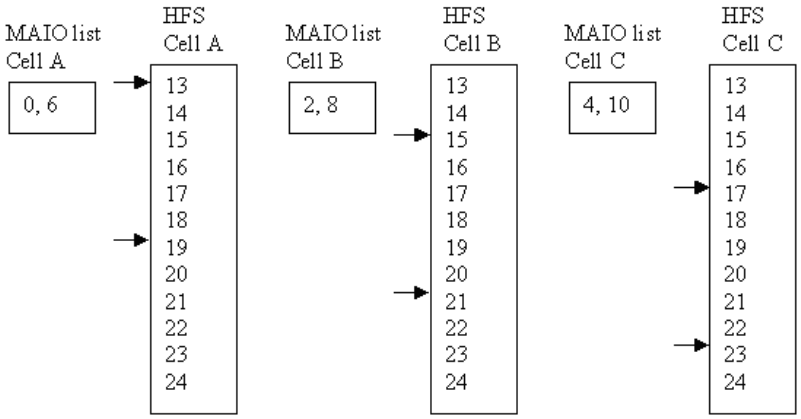
The three solid arrows represent pointers for the frequencies of the three TRXs in the cell. The position of the pointers varies from one TDMA frame to another according to the hopping sequence, as indicated by the dashed arrow. The offset between the pointers is given by the MAIO numbers 0, 2 and 4 and remains constant. Since the MAIO list in the example contains only even MAIO numbers, the use of adjacent frequencies in the cell is avoided.

Example of MAIO Lists for FLP-1/1

When synthesizer hopping is used at a site with three sector cells, the cells are synchronized within the site in order to achieve orthogonal hopping. For FLP-1/1, orthogonal hopping means that all three cells use the same HFS and HSN, and

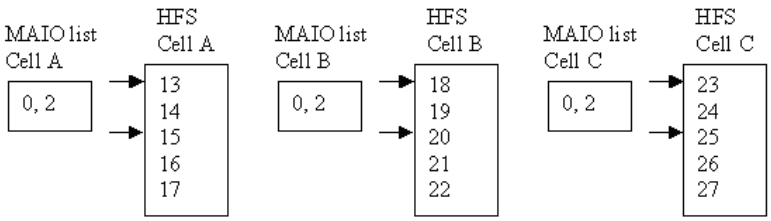
frequency collisions are avoided by giving all TRXs at the site different MAIO numbers.

The MAIO numbers used in a cell are collected in a MAIO list. The MAIO lists of the three cells must not contain the same MAIO number, as shown in the following illustration. It is assumed that ARFCNs 1 to 12 are used for the BCCH, allocated to a separate channel group.



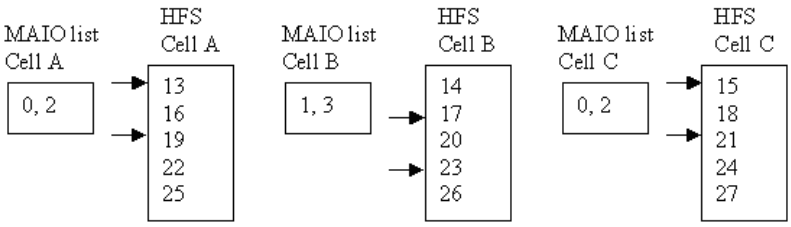
Example of MAIO Lists for FLP-1/3 with Blocked HFSs

For FLP-1/3, the three cells use different HFSs without common frequencies. If the cells use the same HSN, MAIO lists are designed to avoid the use of adjacent channels in the three cells. A list with blocked HFSs is shown in the following illustration:



Example of MAIO Lists for FLP-1/3 with Staggered HFSs

With staggered HFSs, the MAIO lists are designed as shown in the following illustration:



The odd numbers in the MAIO list of cell B are necessary to avoid adjacent channel interference that would occur if even numbers were used.

When MAIO values are not entered for a cell, the BSS creates a default MAIO list of the same size as the HFS. The list consists of even numbers (starting with 0) followed by odd numbers. If there are five frequencies in the HFS, the default MAIO list contains the five MAIO numbers 0, 2, 4, 1, 3. The default MAIO list is used in many, but not all, cases.

Hopping Frequency Sets

TEMS CellPlanner supports hopping frequency sets containing some or all available ARFCNs. To use FLP-1/3, the hopping frequencies must allocated to three HFSs with either blocked or staggered frequencies.

One of the three HFSs is assigned to the hopping channel group in every cell. Note that the number of frequencies in each HFS must exceed the maximum number of hopping transceivers in any cell.

To use FLP-1/1, all hopping frequencies must be allocated to one HFS. With blocked BCCH/TCH allocations, for example, ARFCNs 1 to 12 are used for BCCH planning and ARFCNs 13 to 24 are allocated to the HFS. With staggered BCCH/TCH allocations, the odd ARFCNs are used as BCCH and the even ARFCNs are allocated to the HFS.

If two channel groups are used in each cell, where one of them is a non-hopping BCCH channel group, the BCCH frequencies are planned separately, either manually or by optimizing a frequency plan. Then a HFS is allocated to the hopping channel group in every cell, using either FLP-1/1 or FLP-1/3.

If there is only one channel group in every cell (that is, no dedicated BCCH channel group), the planning is done in the same way as for two channel groups, although a BCCH frequency and a HFS are now assigned to the same channel group.

An example of how a frequency plan may be created for 12 cells (#1 to #12), using 12 BCCH frequencies (ARFCNs 1 to 12) and three blocked HFSs, is shown in the following table:

#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
1	2	3	4	5	6	7	8	9	10	11	12
13	18	23	13	18	23	13	18	23	13	18	23
14	19	24	14	19	24	14	19	24	14	19	24
15	20	25	15	20	25	15	20	25	15	20	25
16	21	26	16	21	26	16	21	26	16	21	26
17	22	27	17	22	27	17	22	27	17	22	27

Hopping Sequence Numbers

You can allocate hopping sequence numbers (HSNs) to all cells with hopping channel groups. For unsynchronized cells, interference is minimized by performing HSN planning, using all HSNs from 1 through 63. At a site with three synchronized cells performing orthogonal frequency hopping by MAIO planning, the same HSN must be assigned to all three cells. Hopping sequence numbers are planned either manually or optimizing frequency plans.

MAIO Lists

You can create MAIO lists manually. Examples of MAIO lists for FLP-1/1 and FLP-1/3 are shown in preceding tables and illustrations.

MAIO lists or individual MAIO numbers are allocated to all cells with hopping channel groups. Using default MAIO numbers in a cell, TEMS CellPlanner inserts a MAIO list consisting of the numbers 0, 2, 4, and so forth, in the same way as is done by the BSS.

Calculating Interference Data

The use of FLP has great impact on the interference levels in the GSM network. TEMS CellPlanner models this by considering the allocations of HFSs, HSNs and MAIOs in calculating interference data. TEMS CellPlanner also considers the hopping gain, traffic load and DTX use.

2.11 Effective Subscriber Modeling

GSM subscribers use different frequency bands and service types. Every subscriber must be connected to a cell supporting its frequency band and service type.

In a network supporting HCS, slow and fast moving mobiles are often served by different cells. This is considered in coverage and traffic calculations.

TEMS CellPlanner can model the subscriber features and calculate the effect the features has on the coverage and traffic demand for different cells.

The subscriber features to consider in subscriber modeling include:

Feature	Description
Frequency bands	A GSM network may use one or two frequency bands: • 1 band - Traffic demand is generated by a mix of single-band and dual-band mobile stations. The traffic demand on a cell using one frequency band is dependent on the density of mobile stations of each type and on the cell size. • 2 bands - In a combined GSM 900 and 1800 MHz network, cells of the different frequency bands may have different size and capacity potential. Taking only signal strength into account, cells for the 1800 MHz band would be smaller than the cells for the 900 MHz band. They may never be the strongest servers. The 1800 MHz band may have more available frequencies, so it provides more traffic capacity than the 900 MHz band, but the 900 MHz band may be highly loaded by single-band mobile stations. Traffic served by cells in each frequency band can be controlled by using HCS. Dual-band mobiles are directed to cells with spare capacity instead of using the strongest cell. Larger and stronger cells (typically GSM 900) do not become congested when the traffic from both dual-band mobile stations and GSM 900 single-band mobile stations is increased, since dual-band mobile stations use spare capacity in GSM 1800 cells.

Feature	Description
Service types	A mobile station uses various types of speech and data services, including: • FR speech • HR speech • HSCSD • ECSD • GPRS • EGPRS Speech, HSCSD and ECSD service types create circuit switched traffic demand, while GPRS and EGPRS create a packet switched traffic demand. A mobile station capable of data service may use more than one timeslot, increasing the user data rate compared to a 1-slot mobile.
Slow / fast moving mobiles	A GSM network using Hierarchical Cell Structures (HCS) may have macrocells, smaller microcells and larger umbrella cells. Traffic is directed to the cell layer with the highest capacity, normally the microcells. However, since the microcells are small, a fast moving mobile station served by microcells would cause a large number of handovers. When the network detects that the number of handovers per time unit exceeds a limit, it directs the fast moving mobile station to cell layers with larger cells, that is, macrocells and umbrella cells. This is done by using Basic ranking instead of HCS ranking for fast moving mobile stations. Basic ranking takes only signal strength into account. Slow mobile stations use HCS ranking.

GSM Subscriber Modeling in TEMS CellPlanner

One or more mobile station types must be defined before a GSM analysis occurs. The properties of a mobile station type affect calculations in TEMS CellPlanner.

The number of timeslots used by the mobile station is important for the achieved throughput in the calculated traffic performance, but does not affect the choice of a best server.

Best Server Display

Choosing a best server for the mobile station is affected by:

- Frequency band(s)
- GSM Service Type
- Speed (Slow or Fast moving mobile)

In the BSC, HSCSD and/or GPRS can be switched on or off for all connected cells. When HSCSD is switched off, ECSD is also disabled, and when GPRS is switched off, EGPRS is also disabled.

Cells connected to a BSC also support HSCSD if the feature is enabled in the BSC.

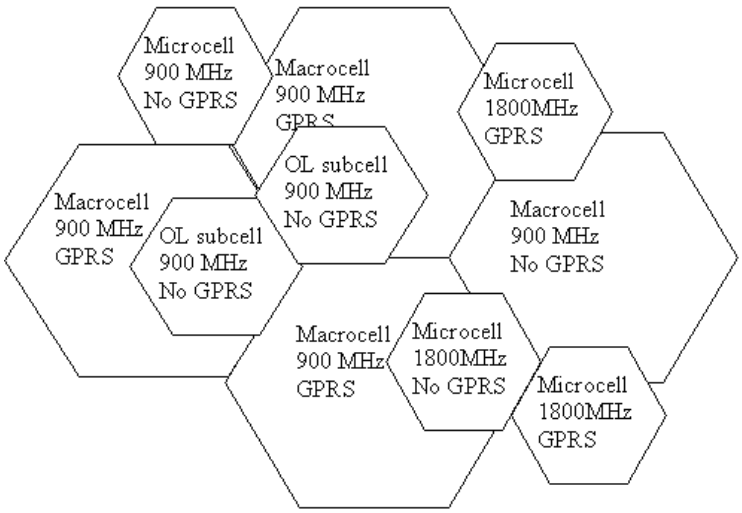
Frequency bands can be configured for every GSM cell to switch the support of GPRS on or off. The number of timeslots capable for EGPRS can be set for each channel group in the cell. A cell containing timeslots capable for EGPRS can support EGPRS and ECSD.

When a cell uses a frequency band and supports the GSM service type used by the mobile station, the cell may become best server for this mobile station.

Selecting a best server for an mobile station depends on the ranking method. HCS ranking is used for Slow mobile stations, and Basic ranking is used for Fast moving mobile stations.

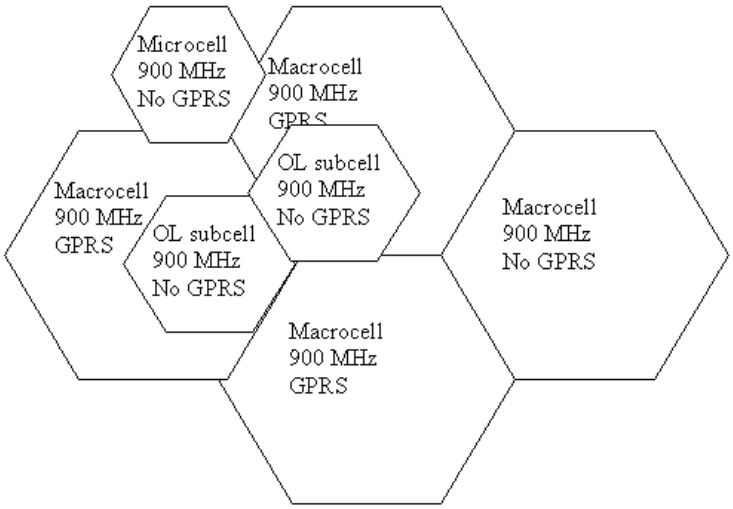
Example Slow Dual-Band Mobile

The following illustration shows a dual-band network with cells belonging to different cell layers and supporting different GSM service types. A slow dual-band mobile station using FR speech would be served by all cells, and the best server display for this mobile station type would look similar to the illustration:.



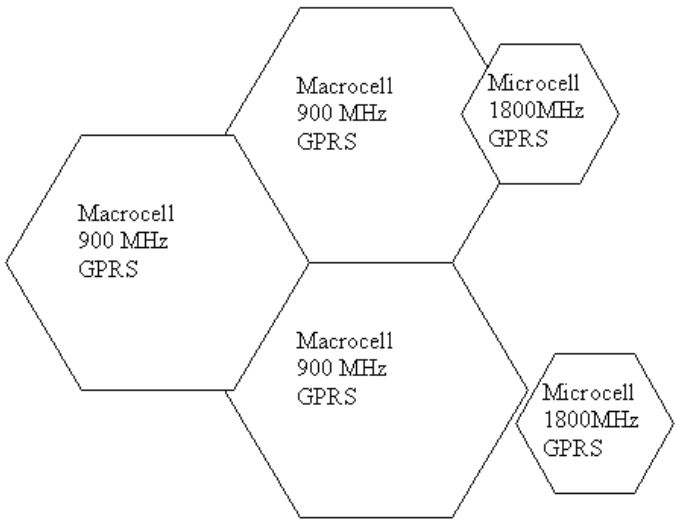
Example Slow Single-Band Mobile

A slow single-band 900 MHz mobile station using FR speech would get a best server display similar to the following illustration, where the 1800 MHz cells have been excluded:



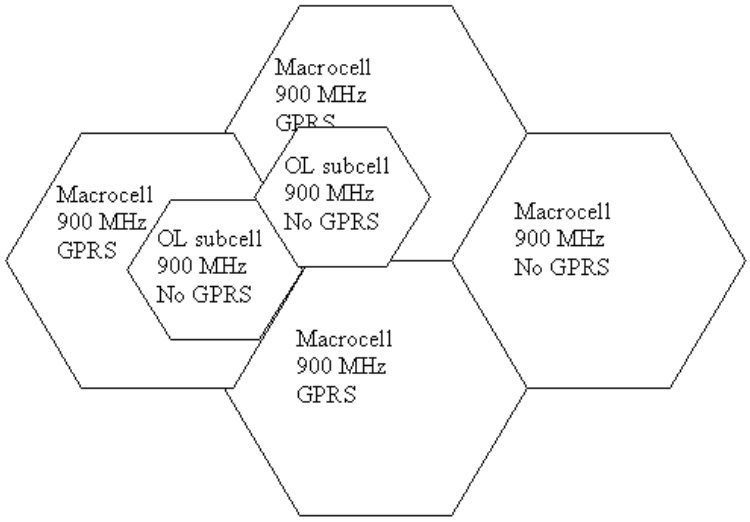
Example Slow Dual-Band Mobile Using GPRS

Slow dual-band mobile stations using GPRS could have a best server display as shown in the following illustration. Here the overlaid subcells and the cells that do not support GPRS have been excluded. Though the remaining cells extend coverage, it is not reflected in the illustration.



Example Fast Dual-Band Mobile

Fast moving mobile stations using FR speech would have the best server display as shown in the following illustration, with microcells excluded:



Traffic Demand

TEMS CellPlanner models the traffic demand for each mobile station type separately, but the total traffic demand is usually generated by a mix of several mobile station types. For each mobile station type, the traffic demand per square kilometer must be defined for every land use code (also called clutter code).

For circuit switched services, the traffic demand is expressed in Erlangs. One erlang (E) corresponds to one active user. For FR speech, one E requires one timeslot in the base station. For HR speech, one E requires ½ timeslot. For HSCSD, one E can require several timeslots.

Packet switched traffic demand is expressed as a data rate in kbit/s. The data rate carried by one timeslot varies dependent on the packet switched service type (GPRS or EGPRS) and the carrier to interference ratio achieved in every pixel.

When the traffic demand for a mix of mobile station types is known, traffic performance is calculated for every cell. For every cell, TEMS CellPlanner calculates a number of parameters, such as total circuit switched load and blocking rate per cell.

3
GSM Analysis Algorithms

This chapter describes the GSM analysis algorithms used in TEMS CellPlanner.

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3.1 Best Server Algorithms

3.1.1 HCS Ranking

In a GSM network, the Hierarchical Cell Structure (HCS) feature can give cells priority in an efficient and safe way. TEMS CellPlanner can model GSM networks with HCS. Without HCS, the serving cell is the cell giving the strongest received signal strength where the mobile is located, appropriate when the level of interference is roughly the same in all cells.

Cells with comparatively weak signal strength may provide valuable capacity while the interference is low. These cells should then be given priority although they are not the strongest ones. One example is small cells, like street cells or indoor cells, normally covered by the surrounding macrocells. Another example is the low loaded band in a dual-band (900 MHz and 1800 MHz) network.

The HCS feature provides the possibility and flexibility to give priority to cells that are not strongest but provide sufficient received signal strength. The appropriate level of the sufficient signal strength mainly depends on co- and adjacent channel interference from the surrounding cells.

Using HCS in GSM Networks

The priority of a cell is given by associating an HCS layer to the cell. Each layer belongs to an HCS band. The smaller the HCS layer number (and HCS band number), the higher the priority. HCS layer and band definitions must consider:

- Traffic distribution strategy among different cells
- Maximum traffic capacity for the cells
- Influence of interference on the cells

Options for HCS

Multi layered HCS using HCS bands *and* HCS layers is available as an optional feature in the Ericsson GSM Base Station System R8, offering two options:

HCS Option	Description
Full HCS	Full HCS allows up to eight HCS layers distributed in ascending order in up to eight HCS bands. Several HCS layers can be assigned to a single HCS band, but a layer can be assigned to only one band. A lower HCS band may only include lower layers compared to a higher HCS band.
Reduced HCS	Reduced HCS makes only one HCS band available and each cell belongs to one of three HCS layers (layer 1, 2 or 3).

Giving Priority to Small Cells

With a mixture of small and large cells, both high capacity and good coverage can be achieved. Microcells and indoor cells with high priority can use low output power and low or indoor antenna positions. Traffic in these cells creates less interference than traffic in a macrocell. Within the confined area of microcells and indoor cells, interference can usually be avoided, so the small cells may provide better quality although the serving cell is not the strongest cell.

The purpose of the higher layer cells is to fill radio coverage holes, to take care of fast moving mobiles by reducing the handover numbers, to provide spare capacity, and to serve as last resort at radio disturbances.

Giving Priority to Frequency Bands

In a combined GSM 900 and GSM 1800 network the cells of the different frequency bands may have different capacity potential. In order to utilize the given capacity it is desired to deviate from the strongest server principle. For example, the cells for the 1800 MHz band may be smaller than the cells for the 900 MHz band, relying on Basic ranking (i.e. only taking signal strength into account). Sometimes they will never be the strongest servers. The 1800 MHz band may have more available frequencies, so it can provide more traffic capacity than the 900 MHz band, but the 900 MHz band may be highly loaded by the single band Mobile Stations (MSs).

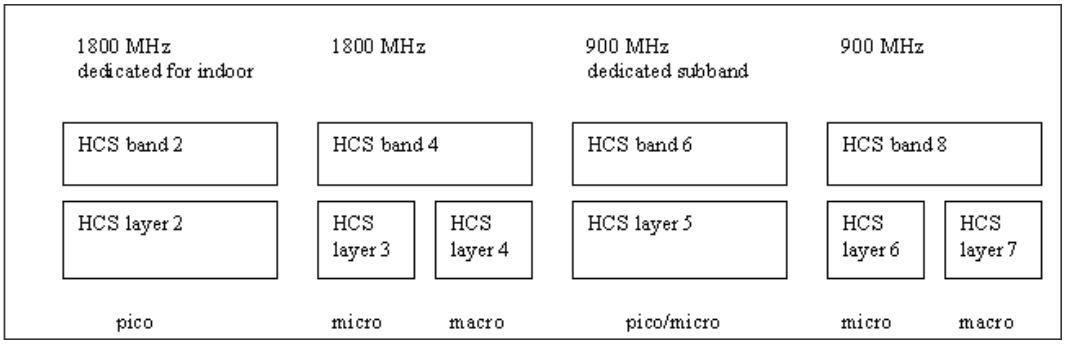
Instead of using strongest cell, the traffic from dual band MSs can be directed to cells with spare capacity. Otherwise the larger and stronger cells (typically GSM 900) would become congested easily as the traffic from both dual band and GSM 900 single band MSs is increased. Consequently, the GSM 900 single band MSs would often be left without service while spare capacity is found in GSM 1800 cells. The objective is to fully utilize the radio capacity while offering sufficient quality.

3.1.2 HCS Bands and HCS Layers

Every cell in the network can be assigned to one of up to eight different HCS layers, numbered from 1 to 8. The HCS layers are of different priorities. The lower the layer number, the higher the priority.

Example of HCS Bands and HCS Layers

An example of how HCS layers can be grouped into HCS bands is shown in the figure below. These assignments are performed for each BSC. The assignments will affect all cells connected to the BSC.



Technically, there is no restriction on frequencies when it comes to assigning cells to different HCS bands. Both 900 MHz and 1800 MHz frequencies can be mixed for a HCS band.

The HCS layers can be distributed over the HCS bands in a variety of combinations as long as their order is maintained. For example all eight HCS layers can be in one HCS band or there can be one HCS layer in each HCS band.

The HCS layers must belong to HCS bands in an ascending order. In the preceding figure HCS layer 4 could be moved to HCS band 6, and HCS layer 5 could be moved to HCS band 4. However, both these actions cannot be performed at the same time, since the ascending structure will then be broken.

Band and Layer Thresholds

Two thresholds exist for each cell:

- *Layer threshold*, set per cell. The cells belonging to a specific HCS layer do not need to have the same layer threshold, which is set individually for each cell.
- *Band threshold*, set per BSC, one for each band, and it affects all cells within that band that are connected to the BSC.

3.1.3 HCS Ranking Algorithm

For every bin in the map window, TEMS CellPlanner sorts all visible cells into two groups. The first group, with the highest priority, is placed on the HCS ranking list, and the second group is placed on the Basic ranking list.

Sorting on the HCS ranking list is done, first checking the band threshold, and then the layer threshold.

When all cells in the bin are processed, the HCS ranking list contains at most one cell from each HCS layer.

Then TEMS CellPlanner sorts the cells in priority order so that the cell with lowest layer number comes first, and so on.

HCS Priority List Sorting

Examples of how the HCS ranking list is sorted is shown in the following tables.

HCS ranking list before sorting in priority order

Cell	Signal strength (dBm)	HCS Band	HCS Layer	Reason for appearing on HCS ranking list
G	-68	8	7	Strongest in band
E	-72	8	6	Strongest in layer
B	-73	4	4	Strongest in band
A	-74	4	3	Strongest in layer

HCS ranking list after sorting in priority order:

Cell	Signal strength (dBm)	HCS Band	HCS Layer
A	-74	4	3
B	-73	4	4
E	-72	8	6
G	-68	8	7

3.1.4 Best Server List

After HCS ranking is performed, TEMS CellPlanner creates a best server list, containing the N best serving cells, taken in priority order from the HCS ranking list. If there are less than N cells on the HCS ranking list, these cells followed by the required number of cells from the Basic ranking list, taken in order of descending signal strength. The number N before best server plots are generated may be set.

For MSs defined as fast moving, HCS ranking is not performed. Instead, Basic ranking is performed, placing the cells in order of descending signal strength.

The Coverage plot uses only Basic ranking, and thus shows the signal strength of the strongest cell. When the mouse pointer is placed on a bin in the map window, the cell identity and received signal strength of the strongest cell, and the same data for the 2nd strongest cell, are displayed in the status bar below the map window.

3.2 Interference Table Calculations

TEMS CellPlanner can calculate interference tables for each traffic case, or for a combination of traffic cases. The tables contain the co-channel and adjacent channel interfered area and traffic for every combination of a serving cell and an interferer. A traffic demand mix is used to calculate the interfered traffic.

The interference table is used for Automatic Frequency Planning (AFP).

When the interference table calculation is invoked, TEMS CellPlanner displays a list of the valid traffic cases (those that were selected for the best server analysis). For each traffic case, a weight factor is for the interfered area calculation and another weight factor for the interfered traffic calculation.

3.2.1 Interfered Area Equation

The interfered area in a serving cell, caused by an interfering cell, is calculated as the weighted average of the interfered areas for all included traffic cases. For two traffic cases, 1 and 2, with the area weights wa1 and wa2 and the absolute co-channel interfered areas Aco1 and Aco2, the weighted average of the absolute co-channel interfered area becomes:

$$Aco_ave = (wa1 * Aco1 + wa2 * Aco2) / (wa1 + wa2)$$

3.2.2 Interfered Traffic Equations

The same applies to interfered traffic, provided that there is a valid traffic density for each traffic case. With the traffic weights wt1 and wt2 and the absolute co-channel interfered traffic Tco1 and Tco2, the weighted average of the absolute co-channel interfered traffic becomes:

$$Tco_ave = (wt1 * Tco1 + wt2 * Tco2) / (wt1 + wt2)$$

A traffic demand mix is selected containing a traffic demand for each selected traffic case. If the traffic demand mix does not contain any traffic demand for one of the selected traffic cases, the interfered traffic is set to zero for this traffic case when the weighted average is calculated.

3.3 Interference Analysis Algorithms

3.3.1 Interference in GSM Networks

The quality of the connection to a GSM mobile depends on the strength of the wanted signal and the total strength of all interfering signals. Good quality primarily requires that the strength of the wanted signal exceeds a threshold value. When this requirement is met, the most important influence on the quality comes from the co-channel interference. The adjacent channel interference also affects the quality, but to a smaller extent, since adjacent channels are attenuated by channel filters.

The relation between the received powers of the wanted and interfering signals is denoted by carrier to interference ratio (C/I), and is usually expressed in dB.

3.3.2 Factors Affecting Interference

The following table describes some factors affecting interference analysis:

Factor	Description
Adjacent Channel Attenuation	The interference on frequencies adjacent to the wanted carrier attenuated by channel filters. The adjacent channel attenuation is usually given in dB.
DTX	During a speech call, the transmission can be shut off during silent periods to reduce the average interference hitting other connections. This is known as discontinuous transmission (DTX) used both in the uplink and the downlink.
Power Control	Power control used both in the uplink and the downlink to reduce the overall interference level. The reduction of the average downlink interference generated by a cell is expressed as a power control factor.
Traffic Load	The average interference in a GSM network increases with the traffic in the cells. In the worst case, every timeslot on every transceiver (TRX) would be used all the time, giving a relative traffic load of 1 (100%). In reality, even during the busy hour, the load is lower than 100%, and the average interference hitting other cells becomes lower.
Carrier Zero Filling	To assist the GSM system in handover, the mobiles must make repeated measurements on the BCCH frequencies of surrounding cells. All cells must always transmit on the BCCH frequency, Carrier Zero. This is known as *carrier zero filling*.
Frequency Hopping	Baseband hopping and synthesizer hopping.

3.3.3 Factors Considered in Frequency Hopping

TEMS CellPlanner supports two types of frequency hopping: baseband hopping and synthesizer hopping. Transmission is divided into frames transmitted on the same or different frequencies. The two hopping types differ in if the individual TRXs are changing frequency or not.

Baseband Hopping

For baseband hopping each TRX is allocated with a fixed frequency and the connections alternate between TRXs. Using a filter combiner tuned to a fixed frequency for each TRX, radio transmitters are connected to the antenna.

Synthesizer Hopping

For synthesizer hopping the connections do not change TRX. The TRXs are tuned to use a new frequency between each frame. It is not possible to use a filter combiner. Instead the radio transmitters must be connected to the antenna using hybrid combiners not tuned to a specific frequency.

Frequencies are selected from a hopping frequency set (HFS). An HFS is a list of frequencies used by the hopping TRXs in a cell. The frequency used for each frame is pointed out by a hopping sequence. The hopping sequence is identified by a hopping sequence number (HSN). Since two TRXs in a cell must not use the same frequency at the same time, the TRXs are given different frequency offsets called MAIO values.

Frequency Diversity Gain

Rayleigh fading is wavelength dependent and affects the received signal strength differently on different frequencies. The receiver in a frequency hopping connection can compensate for a fading dip on one of the hopping frequencies by using redundant information received on other frequencies. A frequency hopping connection is less vulnerable to Rayleigh fading than a connection using a fixed frequency, and frequency hopping improves the effective carrier to interference ratio (C/I) seen by the receiver. The improvement is expressed as a frequency diversity gain that increases with the number of hopping frequencies.

Fractional Load

Synthesizer hopping makes it possible to hop on more frequencies than there are TRXs. Each frequency is used only a fraction of the time in each cell. By planning the MAIO values together with the HFSs and HSNs, the interference in the network can be minimized.

The average interference generated on each frequency becomes only a fraction of the interference generated if the number of frequencies equals the number of TRXs. This is known as *fractional load*.

Synchronized Hopping

The synthesizer hopping cells at a base station site can be synchronized so that their frequency hops are performed simultaneously. Even if the cells are using the same hopping frequency set (HFS), they can be made to hop on different frequencies at every point of time. This is known as *orthogonal hopping*, achieved by MAIO planning. With orthogonal synthesizer hopping, both co-channel and adjacent channel interference between cells at the same site can be avoided if a sufficient number of hopping frequencies is available.

3.3.4 Data Input Affecting Interference Analysis

Project Settings Parameters

The following project settings parameters affect interference analysis.

Parameter	Description
Adjacent channel interference gain (default -18 dB)	Adjacent channel interference gain added to the adjacent channel interference (in dB) hitting all cells
DTX factor (default 0.5)	DTX must be enabled for each cell. The interference (in watts) generated by the cell multiplied by the DTX factor.
Power control factor (default - 2 dB)	Downlink power control must be enabled for each cell. The power control factor is added to the interference (in dB) generated by the cell.
Frequency diversity gain, (default values between 0 and 3 dB)	The frequency diversity gain for the appropriate number of hopping frequencies added to the C/I (in dB) and calculated for all baseband or synthesizer hopping channel groups, depending on the number of hopping frequencies.

Base Station, Cell, and Channel Group Parameters

Individual frequencies, frequency groups, and hopping frequency sets must be planned for the channel groups in all cells.

If desired, DTX and power control can be enabled per cell.

Synchronized frequency hopping can be enabled for every base station. MAIO planning may then be done with synthesizer hopping channel groups in all cells of a site.

Input from Traffic Analysis

The traffic load per cell can be imported or calculated by TEMS CellPlanner. When traffic is distributed on the available traffic channels (TCH timeslots) in each cell, the average load per timeslot is found. The average load can be stored per cell and is considered in the interference analysis.

If traffic analysis is not performed, the average load per cell defaults to 1. This value corresponds only to the BCCH frequency generated interference (due to Carrier Zero filling), because no transmission exists on the TCH frequencies.

The average load is set to zero to find the worst case interference.

3.3.5 Description of Interference Analysis Algorithms

Prerequisites for Calculation

Before running interference analysis, best server analysis must be run to find the serving cell for every bin. The received signal strength from the serving cell (or overlaid sub-cell) is used as the "C" in the carrier to interference ratio (C/I) calculations.

The received signal strengths from all other cells within the prediction radius are calculated by the pathloss calculation function. All signals that can use a frequency coinciding with or adjacent to a frequency used in the serving cell are regarded as *interference contributions*. These contributions are put together to make up the "I" in the C/I.

The probability that an interfering cell transmits in a certain timeslot is less than 100%, except for the BCCH frequency which must always be transmitted. For TCH frequencies, the traffic load, DTX, and power control must be considered, as well as the use of frequency hopping and fractional load, when applicable. The algorithm cannot simply add the powers of the interference contributions.

When transmission probability is less than 100% due to traffic load, fractional load (for synthesizer frequency hopping) and discontinuous transmission, the effective interference is calculated using the estimated average BER.

Interference Analysis Calculation Method

The method starts with a calculation of the C/I for every interference contribution. The effect of power control is considered by adding a constant (in dB) to this C/I. Then a conversion of the C/I is performed for every interference contribution to a bit error rate (BER) value by a built-in table. The BER values are added, taking the transmission probabilities into account.

When BER contributions from different interferers are summed, the possibility of multiple errors hitting the same bit must be considered. Consequently, the resulting BER cannot exceed 0.5. The sum is given by the following equation, used recursively if there are more than two BER contributions:

$$\text{sum BER}(k) = \text{BER}(1) + \text{BER}(2) - 2 \times \text{BER}(1) \times \text{BER}(2)$$
$$k = 1,2$$

A conversion from BER back to C/I is then performed. The effect of frequency diversity gain is taken into account by adding a constant (in dB) to this C/I, giving the final C/I displayed.

The calculation method takes into account the uneven distribution of the interference over time in a frequency hopping network. However, it does not take into account the non-linear effect that arises when two or more strong interference contributions are added, causing a high BER during a short time. Since this occurs with low probability, the method will underestimate the BER only slightly.

BER Contributions

The serving cell (or overlaid sub-cell) and its signal strength are found for every bin in the best server analysis results. The received signal strengths of the possible interferers for the bin were calculated by pathloss calculation.

The C/I on the i:th frequency while the K:th cell is transmitting on the j:th frequency, C/I(K,i,j) is calculated from:

$$C/I(K,i,j) = P_{SC}(i) - [\ P_{IC}(K,j) + PCF(K) + Dx(i,j)\ ]$$

where

P_{SC}(i) is the received power in dB from the serving cell on the i:th frequency

P_{IC}(K,j) is the received power in dB from the K:th cell on the j:th frequency

PCF(K) is the power control factor for the K:th cell

$$Dx(i,j) = \begin{cases} Dc \text{ if } f(i) - f(j) = 0 \\ Da \text{ if } |\ f(i) - f(j)\ | = 1 \\ -\infty \text{ otherwise} \end{cases}$$

Depending on the display, Dc and Da are as follows:

Co- or Adjacent Channel	Formula
Co-channel only	Dc = 0 dB, Da = -∞
Adjacent channel only	Dc = -∞, Da = AF dB
Co- and adjacent channel	Dc = 0 dB, Da = AF dB

When j indicates a frequency used as Carrier Zero (the frequency on which the BCCH is transmitted) in the *K:th* cell, downlink power control is not allowed, and:

$$C/I(K,i,j) = P_{SC}(i) - [\ P_{IC}(K,j) + Dx(i,j)\ ]$$

Transmitter power can be different in a cell (underlaid sub-cell) and its overlaid sub-cell. This means that the received signal strengths are dependent on if the i:th and j:th frequencies are allocated to the respective underlaid sub-cell or overlaid sub-cell.

The BER on the i:th frequency while the K:th cell is transmitting on the j:th frequency, BER(K,i,j), is calculated from C/I(K,i,j) by the C/I to BER conversion function, denoted by F:

$$BER(K,i,j) = F(C/I(K,i,j))$$

Transmission Probability

The transmission probability PT(K,i,j) is the probability that the interfering K:th cell transmits on the j:th frequency, given that the interfered connection uses the i:th frequency. It is calculated in different ways depending on the type of frequency hopping in the interfering and interfered cells.

Fixed and Baseband Hopping Frequencies

The interfering cell always has a fixed BCCH frequency. This frequency, also called Carrier Zero, must be allocated to one of the channel groups in each cell. In a GSM network, it is possible to include Carrier Zero in a FH channel group (though the first timeslot on Carrier Zero carrying the BCCH, will not hop).

If the j:th frequency in the K:th cell carries the BCCH, Carrier Zero filling is performed, and then:

$$PT(K,i,j) = 1$$

Else if j denotes any other fixed or baseband hopping frequency in cell K, then:

$$PT(K,i,j) = L(K)\ V(K)$$

where the load factor L(K) can be defined, or calculated from traffic data, and V(K) is the voice activity factor (DTX factor).

Unsynchronized Synthesizer Hopping

If the interfering frequency, indexed by j, is synthesizer hopping but the serving cell and cell K are not synchronized to each other, or if the cells are synchronized but the channel groups containing the interfered frequency i and the interfering frequency j are not performing synchronized hopping (due to HFSs of different sizes or different HSNs), then the interference will hit randomly. The probability of transmission becomes:

$$PT(K,i,j) = L(K)\ V(K)\ FL(K,h)$$

Here, FL(K,h) is the fractional load on the h:th channel group, containing the j:th frequency of cell K. FL(K,h) is found by dividing the number of TRXs with the number of frequencies in the channel group.

Synchronized Synthesizer Hopping

If the interfered frequency, indexed by i, is synthesizer hopping and the serving cell and cell K are synchronized to each other, and the channel groups containing the interfered frequency i and the interfering frequency j have HFSs of the same size m and use the same HSN, then the channel groups perform synchronized hopping. Then the probability of transmission becomes:

$$PT(K,i,j) = L(K)\ V(K)\ P(K,j \mid i)$$

P(K,j | i) is the probability that cell K transmits on the synthesizer hopping frequency j, given that the serving cell transmits on frequency i. When the values of P(K,j | i) are calculated, the MAIO lists of the two channel groups are taken into account by the following algorithm.

Per Carrier Interference Calculation

The total BER on the i:th frequency, BER(i), is calculated by recursive use of the BER summation formula, denoted by "sum". The sums are taken over all interfering cells and frequencies in the working set of the current bin:

$$BER(i) = \sum_{j} \sum_{K} BER(K,i,j)\, PT(K,i,j)$$

These results are not displayed but used as input to the calculations for the displays.

The use of the downlink power control factor and the transmission probability PT(K,i,j) (dependent on traffic load, DTX factor and fractional load) reduces the interference for all display types, compared to the expected interference if these factors were not considered.

3.3.6 Calculations for Interference Displays

TEMS CellPlanner generates several types of interference displays. For most display types, every bin in the map window is displayed with a specific color to indicate the carrier to interference ratio (C/I), that is, the ratio between the received signal strength of the serving cell and the co-channel and/or adjacent channel interference.

Display Criteria

For all display types, the following are taken into account, when applicable:

- adjacent channel attenuation
- Traffic load
- DTX factor
- Power control factor
- Fractional load

This means that interference is reduced, compared to what would be expected if these factors were not considered.

For each display type, the bins are colored according to:

- The identity of the serving cell
- The identity of the worst interfering cell
- The calculated C/I value

In case no interference is present, C/I becomes infinite, and the upper C/I limit of the application (41 dB) is displayed.

When interference is stronger than the wanted signal, negative C/I values are displayed. If C/I becomes less than the lower C/I limit of the application (-13 dB), the limit value is displayed.

No Results Displayed

Nothing is displayed for a bin if:

- The bin has no serving cell due to too low received signal strength or too long propagation time
- The bin is outside the signal strength prediction radius

Worst Interference Display

The Worst Interference display shows the worst co-channel or adjacent channel C/I of any frequency. C/I can be calculated for co-channel or adjacent channel interference.

The display can be made for BCCH carriers, TCH carriers, or both.

The status bar shows the ARFCN of the worst interfered frequency and the identity of the strongest interfering cell on this frequency. The C/I in dB for this frequency is also shown.

The BER(i) values are calculated. The values for all frequencies are compared, and the highest value selected:

$$BER(ih) = \max_{i} BER(i)$$

The BER value is translated back into a carrier to interference ratio (C/I) value of the worst interfered frequency by the inverse of the C/I to BER conversion function, denoted by F^{-1}:

$$C/I(ih) = F^{-1}(BER(ih))$$

For co-channel interference, the C/I(K,ih,ih) calculated values are compared in order to find the index K of the cell giving the lowest C/I:

$$Kworst = \{K: C/I(K,ih,ih) = \min_{K1} C/I(K1,ih,ih)\}$$

Kworst is saved for later presentation with the ARFCN of the worst interferer, f(ih).

For adjacent channel interference, the C/I(K,ih,j) values, where çf(ih) - f(j)÷ = 1, are compared in the same way, and the index Kworst of the cell giving the lowest C/I is saved for later presentation with the ARFCN of the worst interferer, *f(j)*.

The C/I for the worst interfered frequency, C/I(ih), is displayed, color encoded for every bin.

Interfered Carrier Type Display

The Interfered Carrier Type display shows the C/I, found for either the frequency on which the BCCH is transmitted or the TCH frequencies. C/I can be calculated for co-channel, adjacent channel, or combined co- and adjacent channel interference.

The status bar shows the identity of the serving cell. The C/I in dB is shown for the BCCH, or the average C/I in dB for all TCH frequencies.

When BCCH is selected, then for every bin the BER is calculated for Carrier Zero (denoted by i0) of the bin's serving cell. The ARFCN, f(i0), of Carrier Zero is saved for later presentation. The BER(i0) is calculated and is then translated back into a C/I value by the inverse C/I to BER conversion function:

$$C/I(i0) = F^{-1}(BER(i0))$$

When TCH is selected, the same calculation as for the Average Connection display is performed, but for each cell restricted to the frequencies included in the TCH layers.

The C/I of the interfered carrier type, C/I(i0) or $C/I_{average}$ is displayed, color encoded for every bin.

Worst Connection Display

The Worst Connection display shows the worst C/I, calculated for any fixed frequency or hopping frequency set used for the connection. C/I can be calculated for co-channel, adjacent channel, or combined co- and adjacent channel interference.

The display can be made for BCCH carriers, TCH carriers, or both.

The status bar shows the identity of the serving cell, plus the ARFCN of the worst interfered frequency or an indication that the worst interfered connection is a HFS, and the worst connection C/I in dB.

The average BER, $BER_{FH}(h)$, of the h:th FH connection (i.e. the h:th FH channel group) is calculated by summing over all frequencies in the HFS:

$$BER_{FH}(h) = \sum_{i=1,m} BER(i) / m$$

For simplicity, we assume that the frequencies in the HFS are indexed by i with the range 1 to m. This is an average value, not a summation of interference contributions, so the recursive summation formula defined above is not used. When the BCCH is included in the FH channel group, then the BER for Carrier Zero is included in the sum.

The BER(i) values for the fixed frequencies used in the cell are translated back into C/I values by the inverse of the C/I to BER conversion:

$$C/I(i) = F^{-1}(BER(i))$$

For a FH connection with *m* frequencies, the $BER_{FH}(n)$ values are translated back into C/I values, and the frequency diversity gain FDG(*m*) is added:

$$C/I_{FH}(h) = FDG(m) + F^{-1}(BER_{FH}(h))$$

The C/I values for all fixed frequencies and all FH channel groups are compared, and the lowest value is selected:

$$C/I_{worst} = \min\{ \min_{h}\{C/I_{FH}(h)\}, \min_{i}\{C/I(i)\} \}$$

$$i_{worst} = \{ i: C/I(i) = C/I_{worst} \}$$

C/I_{worst} and the ARFCN, $f(I_{worst})$, of the worst connection are saved for later presentation. If a FH channel group gives the lowest C/I, then the ARFCN is replaced by the text string "Channel group n" where n is the ID of the channel group.

The value of C/I_{worst} is displayed, color encoded for every bin.

Average Connection Display

The Average Connection display shows the average C/I, calculated over all fixed and hopping frequencies used for the connection to that bin. C/I can be calculated for co-channel, adjacent channel, or combined co- and adjacent channel interference.

The display can be made for BCCH carriers, TCH carriers, or both.

The status bar below the map window shows identity of the serving cell of the bin where the mouse pointer is located. The average C/I in dB for that bin is also shown.

The reduction of the BER for a FH connection (corresponding to a FH channel group) due to the frequency diversity gain is calculated first:

$$C/I_{FH}(h) = FDG(m) + F_{-1}(BER_{FH}(h))$$

$$BER_{FHred}(h) = F(C/I_{FH}(h))$$

The total BER is then calculated as the average of $BER_{FHred}(h)$ and BER(i) over all connections as:

$$BER_{TOT} = [\sum_{h} n(K,h)\, BER_{FHred}(h) + \sum_{i=1,nfix} BER(i)] / [\sum_{h} n(K,h) + nfix]$$

where n(K,h) is the number of TRXs in the h:th FH channel group, and the sum is taken over the nfix TRXs in the fixed frequency channel group(s) in cell K. The fixed frequency TRXs are assumed to be numbered from 1 to nfix.

When the BCCH is included in a FH channel group, the timeslot carrying the BCCH is not hopping, but this is not taken into account.

The average value BER_{TOT} is translated back into an average C/I value by the inverse C/I to BER conversion:

$$C/I_{average} = F^{-1}(BER_{TOT})$$

This value is displayed, color encoded for every bin.

3.4 Traffic Analysis Algorithms

TEMS CellPlanner calculates and displays traffic demand and other traffic parameters for one or more services.

The application can calculate traffic parameters per cell for a circuit switched (CS) service, for a packet switched (PS) service, and for the combined load of all services.

The traffic analysis for halfrate (HR) speech as well as of high speed circuit switched data (HSCSD) and enhanced circuit switched data (ECSD) is presently not available in TEMS CellPlanner.

Traffic analysis requires a best server identity results and a traffic raster valid for each selected service. For PS services, the average interference results can be used optionally.

The traffic analysis can calculate a number of parameters, such as:

- CS traffic load
- PS traffic load
- Expected throughput and data rate, per TCH timeslot for different GSM service types with terminals using varying numbers of timeslots

Traffic analysis can be performed for every cell for a GSM service type or for the combined load of several services.

GPRS/EGPRS/EDGE Evolution

When TEMS CellPlanner calculates the best server results and performs traffic analysis for GPRS, EGPRS or EDGE Evolution, only the cells with capability for this service are considered.

Service Types

A GSM network handles traffic of the following service types:

- FR speech
- HR speech
- HSCSD
- GPRS
- ECSD
- EGPRS
- EDGE Evolution

All GSM cells can handle FR speech, but the capability to handle other service types can be different for different cells, and for the overlaid/underlaid sub-cells within a cell. The traffic load on a sub-cell is restricted to the service types supported by the sub-cell.

3.4.1 Traffic Analysis Function

Traffic Load

The traffic load can be generated for mix of several terminal types. Several terminal types may use the same service. All terminal types and services must be analyzed and combined in order to calculate the traffic parameters for services in a certain bin or cell. The offered traffic in a cell for a specific service is the sum of the traffic generated by one or more traffic cases.

Traffic Demand Calculations

TEMS CellPlanner can calculate the traffic demand for:

- Selected CS or PS service
- Blocking for a CS service
- Achieved data rate per timeslot for a PS service
- Required number of TRXs capable of EGPRS or in total for all services
- Achieved throughput per timeslot for a PS service

For every cell the function also calculates the average load (average percentage of used timeslots in the TRXs). The average load can than be applied to the interference calculations. The traffic demand is imposed by the traffic cases for all services considered.

3.4.2 Input for Calculations

The input to traffic analysis comprises:

- One or more traffic cases
- The number of TRXs assigned to every cell
- One or more carrier to channel mappings

Traffic Cases

A traffic case consists of a service, a terminal supporting one or more frequency bands, and a traffic raster. A best server identity results are made for each traffic case.

TEMS CellPlanner supplies mapping curves from C/I to bit rate for different GPRS coding schemes, for EGPR modulation and coding schemes and for EDGE Evolution.

Average interference results may also be used. In cells supporting GPRS, the number of timeslots can be configured for EGPRS and EDGE Evolution can be enabled.

For the calculation of the required number of TRXs, a CS blocking rate must be defined. An Erlang B or Erlang C table is applied by TEMS CellPlanner.

Number of TRXs and Timeslots

For all cells selected using the traffic case, the number of assigned TRXs is stored in the database.

If a cell supports GPRS, the number of timeslots supporting CS-3/CS-4 and the number of timeslots configured for EGPRS can be set to values > 0.

Carrier to Channel Mapping

One or more carrier-to-channel mapping tables can be created, allocating both control and traffic channels. Each row in the table contains the following values.

Row	Number
TRX	The number of TRXs in a sub-cell
N	The total number of channels (timeslots) in the sub-cell
NGPRS	The number of DPDCH
NCTRL	The number of BCCH and SDCCH
NGPRSCTRL	The number of PBCCH

One table may used by underlaid sub-cells containing the BCCH, and another table by overlaid sub-cells not containing a BCCH. Different tables can also be used for cells supporting or not supporting GPRS. The number N_{TCH} of shared TCH channels is calculated as:

$$N_{TCH} = N - N_{GPRS} - N_{CTRL} - N_{GPRSCTRL}$$

For GSM, we have

$$N = 8 \times TRX$$

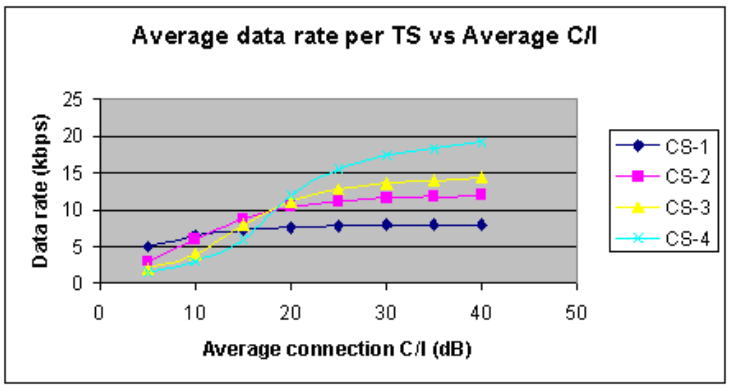
When the number of TCH channels in a cell is needed in the calculations, it can be derived for any number of TRXs.

3.4.3 Modulation and Coding Schemes

Four coding schemes (CS-1 to CS-4) are available for GPRS. Nine modulation and coding schemes (MCS-1 to MCS-9) are available for EGPRS.

For each CS-n and MCS-n, the achievable data rate is set in a pre-defined data rate versus C/I table. The default table may be edited by a qualified user.

An example of four CS-n curves is shown in the following illustration:



TEMS CellPlanner can automatically calculate the best achievable data rate in every bin for GPRS or EGPRS when the average connection C/I has been calculated, as well as for EDGE Evolution. If the average connection C/I results are not available, then C/I = 12 dB is used.

3.4.4 Erlang Tables

The Erlang B or Erlang C table is derived from Erlang's equations (not given here). The table gives the number of required traffic channels when the offered traffic in Erlangs and the desired blocking rate in percent are input.

The inverse Erlang table, denoted as $Erl(n_{CS},A_{CS})$, delivers the blocking rate when the available number of TCH timeslots is given and the offered traffic has been calculated.

E_{FR} (blocking for FR speech) is calculated from n_{CS} (the number of available timeslots for CS traffic) and A_{CS} (the total offered CS traffic) by the Erlang B or Erlang C algorithm:

$$E_{FR} = Erl(n_{CS},A_{CS}).$$

3.4.5 Calculations for CS Services

CS Traffic Demand

The traffic demand of a CS service in a cell is calculated by a summation over all bins for which the cell is the best server. A summation is also performed over all traffic cases using the service.

The traffic demand per cell of the CS service is displayed in the map window by assigning a color to the best server area of the cell. The color represents the traffic demand in the cell in Erlangs according to a color coding scheme.

Achieved CS Blocking Rate

The offered traffic for all CS services in a cell is converted from Erlangs into an equivalent number of timeslots and summed, giving $TS_{CS\text{-}offered}$.

For a given number of TRXs, the channel to carrier mapping valid for the cell gives N_{TCH}. The number of timeslots $TS_{CS\text{-}offered}$ is input, together with N_{TCH}, into the Erlang table, and delivers the blocking rate in the cell.

The achieved CS blocking rate per cell can then be displayed. The bins served by the cell are displayed in the map window with the color that represents the blocking rate according to a color coding scheme.

In case the cell consists of an underlaid sub-cell and an overlaid sub-cell, the program takes into account that the overlaid sub-cell can use free timeslots in the underlaid sub-cell, if needed.

Required TRXs for CS Traffic

The offered traffic for all CS services in a cell is converted from Erlangs into an equivalent number of timeslots and summed, giving $TS_{CS\text{-}offered}$.

The number of timeslots $TS_{CS\text{-}offered}$ is input, together with a given blocking rate, into the Erlang table, and delivers the number of timeslots required for CS traffic in the cell, $TS_{CS\text{-}req}$.

When the cell consists of an underlaid sub-cell and an overlaid sub-cell, the algorithm takes into account that the overlaid sub-cell can use free timeslots in the underlaid sub-cell, if needed.

The number of TRXs needed in the cell, or in each sub-cell, can now be found by the channel to carrier mapping.

If there is no PS traffic, the required number of TRXs can be displayed immediately. The bins served by the cell or sub-cell are displayed in the map window with the color that represents the number of TRXs required to be added or possible to remove, according to a color coding scheme.

After the calculation has been performed, the required number of TRXs may be stored in the database.

3.4.6 Calculations for Achieved PS Data Rate per Timeslot

The analysis may be performed for GPRS, EGPRS or EDGE Evolution, one at a time or at the same time.

For every bin, the maximum achievable data rate per timeslot is calculated and displayed. The program finds the CS-n or MCS-n that gives the highest data rate, taking into account the received signal strength and the C/I in the bin.

If the average connection C/I results have been calculated, then for every bin the average connection C/I, with co- and adjacent channel interference, is used, else the value C/I = 12 dB is used.

The program displays the bins in the map window with the color representing the maximum achievable data rate per timeslot according to a defined color coding scheme.

PS Traffic Demand

One or more of GPRS, EGPRS, and EDGE Evolution, may be selected. All traffic cases using the selected service or services are included in the calculations below, if included in the traffic demand mix.

The traffic demand of a PS service in a cell is calculated by a summation over all bins for which the cell is the best server, and a further summation over all traffic cases using the service.

The traffic demand per cell of the PS service is displayed in the map window by assigning a color to the best server area of the cell. The color represents the traffic demand in the cell in bps according to a defined color coding scheme.

The traffic demand per cell of the PS service can be expressed as a number of timeslots, giving $TS_{GPRS\text{-}demand}$ and $TS_{EGPRS\text{-}demand}$. In this calculation, the traffic demand in each bin is divided by the achieved PS data rate per timeslot. The total traffic demand of the PS services in the cell is calculated:

$$TS_{PS\text{-}demand} = TS_{GPRS\text{-}demand} + TS_{EGPRS\text{-}demand} + TS_{EDGE\text{-}evo\text{-}demand}$$

Required TRXs Capable of EGPRS

The number of required TRXs capable for EGPRS is derived from the traffic demand of EGPRS and EDGE Evolution in the cell expressed as a number of TS, $TS_{EGPRS\text{-}demand}$, calculated.

The program uses the average achieved data rate per TS for EGPRS and EDGE Evolution to calculate the number of TS, $TS_{EGPRS\text{-}req}$ required to serve the offered EGPRS and EDGE Evolution traffic.

The number of $TS_{EGPRS\text{-}req}$ is divided by 8, and the result rounded upwards, giving the number of required TRXs capable of EGPRS.

The bins served by the cell are displayed in the map window with the color that represents the number of TRXs capable for EGPRS, required to be added or possible to remove, according to a color coding scheme.

After the calculation has been performed, the required number of TRXs capable for EGPRS may be stored in the database.

Total Required TRXs

The total required number of TRXs is derived from the traffic demand of all CS and PS services in the cell.

The offered traffic for the CS services is converted from Erlangs into an equivalent number of timeslots, $TS_{CS\text{-}offered}$. The number of timeslots $TS_{CS\text{-}offered}$ is input, together with a given blocking rate, into the Erlang table, delivering the number of timeslots required for CS traffic in the cell.

The traffic demand for GPRS, EGPRS and EDGE Evolution is also expressed as a number of TS. The program calculates the number of timeslots required to achieve the wanted throughput for mobiles with a selected number of timeslots.

The blocked amount of CS traffic in the cell, expressed as a number of timeslots, $TS_{blocked}$, is calculated by the Erlang tables.

The average number of timeslots used by CS traffic is then:

$$TS_{CS\text{-}used} = TS_{CS\text{-}offered} - TS_{blocked}$$

The required number of TS for CS in the cell, $TS_{CS\text{-}req}$, is calculated.

For the given number of TRXs, the number of DPDCHs, N_{GPRS}, is taken from the channel to carrier mapping valid for the cell.

The algorithm calculates the number of timeslots, $TS_{GPRS\text{-}req}$, $TS_{EGPRS\text{-}req}$ and $TS_{EDGE_evo\text{-}req}$, required. The sum of $TS_{GPRS\text{-}req}$, $TS_{EGPRS\text{-}req}$ and $TS_{EDGE_evo\text{-}req}$, is the required number of timeslots for PS services, $T_{SPS\text{-}req}$.

The total required number of TCH plus DPDCH timeslots for all services is then:

$$N_{TS\text{-}req} = \max \{ TS_{CS\text{-}req} + N_{GPRS}, TS_{CS\text{-}used} + TS_{PS\text{-}req} \}$$

For the given number of TRXs in the cell, the number of BCCH and SDCCH channels, N_{CTRL}, and PBCCH channels, $N_{GPRSCTRL}$, are taken from the channel to carrier mapping. The total required number of timeslots is then:

$$N_{req\text{-}tot} = N_{TS\text{-}req} + N_{CTRL} + N_{GPRSCTRL}$$

The total number of required TRXs is found by dividing $N_{req\text{-}tot}$ by 8 and rounding the result upwards.

If the number of required TRXs is not equal to the allocated number of TRXs in the cell, the calculation is iterated with new values of $TS_{blocked}$, $N_{GPRS,}$ N_{CTRL} and $N_{GPRSCTRL}$, until the number of TRXs becomes the same as for the previous iteration. When the cell consists of an underlaid sub-cell and an overlaid sub-cell, the calculation is performed in several steps.

The total required number of TRXs is then displayed. The bins served by the cell or sub-cell are displayed in the map window with the color that represents the number of TRXs required to be added or possible to remove, according to a color coding scheme.

After the calculation has been performed, the required number of TRXs may be stored in the TEMS CellPlanner project.

Achieved throughput in cells

For the given number of TRXs, the channel to carrier mapping gives N_{TCH} and N_{GPRS}. The value of $TS_{CS\text{-}used}$ is calculated. Then we get the available number of timeslots for the PS services:

$$TS_{PS\text{-}avail} = N_{TCH} + N_{GPRS} - TS_{CS\text{-}used}$$

This value is valid for GPRS. For EGPRS and EDGE Evolution, we must also take into account the upper limit set by the number of timeslots configured for EGPRS.

TEMS CellPlanner calculates the maximum possible GPRS, EGPRS and EDGE Evolution throughput as the average achieved data rate per TS multiplied by a traffic load dependent reduction factor (between 0 and 1).

The throughput per timeslot in all cells for GPRS, EGPRS or EDGE Evolution, and an M-slot mobile is then displayed. The bins served by the cell are displayed in the map window with the color that represents the median throughput in kbps according to a color coding scheme.

3.4.7 Display Options for CS Services

TEMS CellPlanner has the following display options for CS services:

- Traffic demand for all CS services in all cells
- Blocking rate for a CS service in every cell supporting the service. The traffic demand imposed by all CS services is taken into account.
- Required total number of TRXs for all services. The load imposed by PS services is taken into account. The need for more TRXs, or fewer TRXs, than are currently allocated can be displayed or reported. The calculated number of TRXs in each cell may be applied to the database.

3.4.8 Display Options for PS Services

TEMS CellPlanner has the following display options for PS services:

- Traffic demand for GPRS, EGPRS or EDGE Evolution in every cell supporting the service
- Achieved maximum data rate per timeslot (TS) for GPRS, EGPRS or EDGE Evolution in every bin
- Required number of TRXs, capable for EGPRS in every cell. The need for more TRXs, or fewer TRXs, than are currently allocated can be displayed or reported. The calculated number of TRXs capable of EGPRS in each cell may be applied to the database.

- Achieved throughput per cell for GPRS, EGPRS or EDGE Evolution in every cell. The traffic demand imposed by all services is taken into account.

3.5 Automatic Frequency Planning Algorithm

3.5.1 Algorithm Input

The cost and separation specification is a list of cost specification items, where each such item specifies the separation requirements, and the cost for breaking this requirements, applicable for the TRXs in the cells selected by the filter related to the cost specification item in question. The separation applies for each TRX selected by the specific filter, relative all other TRXs (regardless of layer) in the cell, site or neighbor cells.

3.5.2 Algorithm Output

The AFP result cost is a list of TRX cost items, where each such item specifies the costs assigned to a specific TRX in the plan calculated by the AFP. The result cost is provided as a calculation result from the algorithm.

The Status is the current algorithm status.

3.5.3 Algorithm User Interface

The main frame of the AFP algorithm is a standard algorithm frame with an input panel and a status panel. Both panels are collapsible.

The input panel is divided into three sub-panels:

- General input
- Separation requirements
- Interference table weights

General Input Sub-Panel

This panel specifies general input parameters, including frequency band; the frequency band to be planned; the AFP will only plan cells belonging to the specified frequency band.

Separation Requirements Sub-Panel

This panel contains the GUI components for editing the separation requirements used by the AFP. The separation requirements consist of a number of separation specifications. To the left is a list, Separation specifications, in which one can add, remove and move separation specifications (i.e. change the priority of them). To the right is an editor for viewing/modifying the parameters of the separation specification selected in the list. The parameters are:

- Name - an explanatory name for the separation spec. e.g. "BSC 0001 cells - BCCH".
- Cell & channel selection - Selects the TRXs for which the separation specification applies. The filter selects which sites to select and the channel type selects to which frequency layer the TRXs shall belong.
- Planning policy - Specifies how the AFP shall treat the selected TRXs.
  a. Plan - the AFP is free to change the carriers
  b. Keep - the AFP may not change the carriers, not even for TRXs that have no carrier assigned. No carrier will be assigned.
  c. Plan unallocated - the AFP may change the carriers of those TRXs that have no carrier assigned; the other may not be altered
- Minimum channel spacings - Specifies the minimum separation between channels within a cell, a site and neighboring cells, respectively

Advanced Options

- Retain explicitly locked channels - When this is checked the AFP considers the explicit lock specified per TRX; otherwise the planning policy determines locking of channels.
- Penalty costs - The cost added for each time a cell/site/neighbor separation rule is violated.

Buttons on the Sub-Panel

- Reload, reloads the values of the currently selected separation specification (abandons modifications)
- Apply, saves the current values (after this modification can not be reloaded) in the currently selected separation specification.
- View, view the resulting planning policy, separations and costs per TRX (useful to see the effects of multiple separation specifications with different filters, planning policies, etc.).
- Save, saves the all separation requirements to an XML file.
- Load, loads separation requirements from file (note that previous separation requirements are removed).

Interference Table Weights Sub-Panel

In this panel the user can select the weights that will be used use to combine the interference tables to one interference table used by the AFP.

The user can select the option to normalize interference table weights so that the weights affect the weighting of interfered area between different traffic cases, but not the overall weighting of interfered area compared with interfered traffic.

The user can view the distribution can be displayed in a pie diagram by pressing the Show/hide pie chart button.

Status Sub-Panel

The status panel displays the algorithm status and is updated each time the algorithm fins a solution better than the previous:

- A graph illustrating the total cost over time
- A table in which each entry contains details about each vertex in the graph

When the algorithm is paused or stopped it is possible to apply the frequency plan using the Apply Plan button. The TRXs are then updated with the carriers from the AFP.

4
File Formats

This chapter describes the formats of files used and created for GSM networks by TEMS CellPlanner.

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GSM Carriers. 4-8
GSM Neighbors. 4-12
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4.1 Antenna File Format

4.1.1 Overview

The antenna import file format has a number of generic traits that apply no matter where the file is being imported from. Antennas can be imported in two different formats into TEMS CellPlanner:

- TEMSCellPlanner/EET
- TEMS CellPlanner T1

The formats of the various antenna files are described in the following sections.

4.1.2 Generic Antenna Traits

This section describes the generic traits of an antenna import file format.

Each of the first 20 lines of the import file has a comment describing the information, the unit or type of the value, and whether it is required or optional. The value may be a number, a floating point or an enumeration type, or a character string, in which case no unit type is provided. The following example shows lines with three types of values.

```
DAPA      ## manufacturer (REQ)
59000     ## model (REQ)
  18.54   ## maximum antenna gain (dBi) (REQ)
          …
2         ## polarization (0:unknown, 1:horz,
          2:vert)  (OPT)
```

To omit a value for an optional item, leave the comment line or a blank line as a placeholder so that there are always 20 lines of file header information.

Horizontal Radiation Pattern

The next set of lines describes the horizontal radiation pattern for the antenna, as in the following excerpt:

```
## Horizontal Radiation Pattern ##
   0.00    -0.01
   1.00    -0.02
   2.00    -0.03
   3.00    -0.05
```

The import utility searches for the pound symbol (#) in the *first* column to indicate the beginning of the horizontal pattern.

0 degrees represents the direction in front of the antenna.

The number of data points given for each pattern is user-defined and they do not have to be evenly spaced. However, the angles for the horizontal pattern should range from 0 to 360 degrees. *The dB values specified for each angle are relative to the maximum antenna gain*. The maximum antenna gain is specified in line 3 of the header file.

Vertical Radiation Pattern

The next set of lines describes the vertical radiation pattern for the antenna, as in the following excerpt:

```
## Vertical Radiation Pattern ##
-179.50   -25.57
-178.50   -25.56
-177.50   -25.60
```

The import utility searches for the pound symbol (#) in the *first* column to indicate the beginning of the vertical pattern.

For the vertical pattern, -180 degrees is behind the antenna, -90 degrees is toward the ground, +90 is directly above the antenna, and +180 is in front of the antenna.

0 degrees represents the direction in front of the antenna.

The number of data points given for each pattern is user-defined and they do not have to be evenly spaced. However, the angles for the vertical pattern should range from -180 to +180.

The following table shows the twenty header lines of a sample antenna import file.

DAPA	## manufacturer (REQ)
59000	## model (REQ)
18.54	## maximum antenna gain (dBi) (REQ)
92.00	## horizontal beamwidth (deg) (REQ)

5.50	## vertical beamwidth (deg) (REQ)
25.00	## front-to-back ratio (dB) (OPT)
1710.00	## minimum operating frequency (MHz) (REQ)
1990.00	## maximum operating frequency (MHz) (REQ)
500.00	## maximum input power (W) (OPT)
50.00	## input impedance (Ohms) (OPT)
1.50	## voltage standing wave ratio (OPT)
6.60	## weight (kg) (OPT)
0.28	## wind area (sq. m.) (OPT)
200.00	## max wind speed (kph) (OPT)
2	## polarization (0:unknown, 1:horz, 2:vert) (OPT)
2	## downtilt (0:unknown, 1:none, 2:elec, 3:mech) (OPT)
	## lightning protection (OPT)
N OR 7/16 DIN	## connector type (OPT)
1.78	## height (cm) (OPT)
0.00	## width (cm) (OPT)
0.00	## depth (cm) (OPT)
ABS	## random type (OPT)

To omit a value for an optional item, leave the comment line or a blank line as a placeholder so that there are always 20 lines of file header information.

4.1.3 Antenna File Formats

Antenna data can be imported from one or several antenna files. For each antenna or for all antennas, an associated frequency band may be selected. A header section begins the antenna file, which must contain at least the antenna name field. The following table describes the fields in the header section.

Field	Description
NAME	Antenna name
MAKE	Make / manufacturer
FREQUENCY	Frequency (MHz)
H_WIDTH	Horizontal beamwidth (degrees)
V_WIDTH	Vertical beamwidth (degrees)
FRONT_TO_BACK	Front to back ratio (dB)
GAIN	Antenna gain (dBi)
TILT	Tilt type (ELECTRICAL/MECHANICAL/CROSS POLAR)
COMMENTS	Additional comments

After the header follow two sections prefixed with the name of the particular pattern that will be described, that is, HORIZONTAL or VERTICAL, and the number

of points. The number of points need not equal 360. Each successive row then contains the variables shown in the following table, separated by a space.

Field	Description
Angle	Angle of data point from the main forward beam direction – anticlockwise (degrees)
Loss	Relative to the maximum (dB)

4.1.4 Antenna Parameter Mapping

The following table shows the mapping of TCP/EET/Planet antenna parameters to TEMS CellPlanner parameters.

TCP/EET/Planet Parameter	TEMS CellPlanner Window and Field
NAME	Antenna Type::User label
MAKE	Antenna Type::Model
FREQUENCY	Antenna Band::Frequency [MHz]
H_WIDTH	Antenna Band::Half Power Beam Width Horizontal [deg]
V_WIDTH	Antenna Band::Half Power Beam Width Vertical [deg]
FRONT_TO_BACK	Antenna Band::Front to Back Ratio
GAIN	Antenna Band::Max Gain Antenna Type::Gain Type = dBi (default)
TILT =	
ELECTRICAL	Antenna Type::Electrical tilt type = MET
MECHANICAL	Antenna Type::Electrical tilt type = NONE
CROSSPOLAR	Antenna Type::Electrical tilt type = NONE
COMMENTS	Antenna Type::Description
VERTICAL	Angle Antenna Band::Vertical Pattern Angle [deg]
<VERTICAL> Loss	Antenna Band::Vertical Pattern Loss [dB]
HORIZONTAL	Angle Antenna Band::Horizontal Pattern Angle [deg]
<HORIZONTAL> Loss	Antenna Band::Horizontal Pattern Loss [dB]
	Antenna Band::Frequency Band
	Antenna Type::Project specific=TRUE
	Antenna Type::Item Number
	Antenna Type::Polarization
	Antenna Type::Cross polar discrimination
	Antenna Band::Frequency range
	Antenna Band::Side Lobe Suppression
	Antenna Band::Max Electrical Down tilt

Example Antenna File Contents

An example antenna file contents is shown below.:

NAME	085_2_18
MAKE	Antennas 'R' Us
FREQUENCY	900
H_WIDTH	85
V_WIDTH	10
FRONT_TO_BACK	0
GAIN	18 dBi
TILT	MECHANICAL
COMMENTS	Standard 85-degree antenna
HORIZONTAL	360
0.0	0.0
1.0	0.0
2.0	0.0
....	
353.0	0.1
354.0	0.1
358.0	0.1
359.0	0.0
VERTICAL	360
0.0	0.4
1.0	0.0
3.0	1.1
...	
355.0	25.4
356.0	16.5
359.0	2.3

The final row is terminated by a carriage return. No additional data should be present after the pattern section, as this will be ignored.

4.2 EET File Format

Antenna Diagrams

TEMS CellPlanner must first import antenna diagrams before they can be used within the application. A header section begins the antenna file that must contain

at a minimum the antenna name field. The complete list of fields is given in the following table:

Field	Description
NAME	Antenna name
MAKE	Make/manufacturer
FREQUENCY	Frequency (MHz)
H_WIDTH	Horizontal beamwidth (degrees)
V_WIDTH	Vertical beamwidth (degrees)
FRONT_TO_BACK	Front to back ratio (dB)
GAIN	Antenna gain (dBi)
TILT	Tilt type (ELECTRICAL/MECHANICAL /CROSS POLAR)
COMMENTS	Additional comments

After the header follow two sections pre-fixed with the name of the particular pattern that will be described, such as HORIZONTAL or VERTICAL, and the number of points. The number of points need not equal 360.

Each successive row then contains the variables shown in the following table, separated by a space.

Field	Description
Angle	Angle of data point from the main forward beam direction - anticlockwise (degrees)
Loss	Relative to the maximum (dB)

An example antenna file is shown below:

NAME	085_2_18
MAKE	Antennas'R'Us
FREQUENCY	900
H_WIDTH	85
V_WIDTH	10
FRONT_TO_BACK	0
GAIN	19 dBi
TILT	MECHANICAL
COMMENTS	Standard 85-degree antenna
HORIZONTAL	360
0.0	0.0
1.0	0.0
2.0	0.0
.....	.....
353.0	0.1
354.0	0.1
358.0	0.1

359.0	0.0
VERTICAL	360
0.0	0.4
1.0	0.0
3.0	1.1
.....	.....
355.0	25.4
356.0	16.5
359.0	2.3

The final row is terminated by a carriage return. No additional data should be present after the pattern section, as this will be ignored.

4.3 GSM Carriers

TEMS CellPlanner can import EET/R2C/Planet 2.7 GSM carrier databases. This type of file has a simple ASCII space-delimited text format, as shown in the following table:

Field	Data Type	Description
Site ID	CHAR	Alphanumeric site identity. This must be the same as the site id in the Site Database file.
Sector	INT	Number representing sector (or GSM cell) for cell site.
Number of Carriers Allocated	INT	Number of carriers allocated (maximum of 80 per cell).
Carrier 1, Carrier 2, etc.	INT	Space separated list of channel numbers.
Number of Carriers Required	INT	Number of carriers required for that sector.
LAC	INT	Location Area Code
Cell ID	CHAR	Alphanumeric cell identity
BCCH	INT	Broadcast Control Channel
BSIC	INT	Base Station Identity Code
-	-	Not used, a "-" must be placed here.
MCC	INT	Mobile Country Code
BSC	STRING	Mobile Switching Center
MSC	STRING	Base Station Controller (up to 6 characters)
UDCP	CHAR	Two character field for the user defined character plot.

Field	Data Type	Description
Carrier Type1, Carrier Type2, etc.	CHAR	Space separated list of carrier types (one per allocated channel).
Number of Carrier Type Demands	INT	The number of carrier types demanded.
Carrier Type1, Demand, Carrier Type2, Demand, etc.	CHAR and INT	Space separated list of carrier type name and carrier type demanded.

Carrier Types

The carrier types database is made up of three separate ASCII text files:

- Carrier names file
- Carrier types file
- Carrier groups file

Carrier Names File

The carrier names file, `carrier_types.names`, holds details of the assignment of names to carriers. An example follows:

HEADER EET V2.7 Carrier Names File. Version 1.0	
NAME	1
INDEX	1
NAME	1026
INDEX	2
NAME	2
INDEX	3
.....	

Carrier Types File

The carrier types file, `carrier_types.types`, holds details of the assignment of carriers to types. An example follows:

HEADER EET V2.7 Carrier Types File. Version 1.0	
NAME	cntrl
SYMBOL	+
MAX_ALLOCATION	1
REQUIRED	5
CARRIER	1
CARRIER	1025
CARRIER	2
CARRIER	1026
.....	

NAME	tch
SYMBOL	-
MAX_ALLOCATION	0
REQUIRED	15
CARRIER	1
CARRIER	1025
CARRIER	2
CARRIER	1026

Carrier Groups File

The carrier groups file, `carrier_types.groups`, holds the details of the assignment of channels to groups. Each line holds space-delimited data on one group. The format is shown below:

Group1 C1 C2 C3 C4 C5 etc.
Group 2 C10 C11 C12 C13 C14 etc.

Group is the group name (CHAR) and C is the channel number (INT). A typical file entry might be as follows:

A1	1	5
A2	9	13
A3	17	21
B1	2	6
B2	10	14
B3	18	22
C1	15	7
C2	11	15
C3	19	23
D1	16	8
D2	12	16
D3	20	24

Group A1 consists of channels 1 and 5, group A2 consists of channels 9 and 13, and so on.

A maximum of 80 frequency groups and a maximum 71 carriers per group can be included in the carrier groups file, which is a constraint of EET/Planet.

Exceptions

TEMS CellPlanner can import and export EET/R2C/Planet 2.7 Exceptions databases. The following tables provide the specification of the file format.

Field	Data Type	Description
Header	CHAR	Contains version information
Optimise_Which	INT	Which threshold to optimize on (used only by optimizing algorithms)
CARRIER_TYPE	CHAR	Carrier type identity
CARRIER_TYPE	FLOAT	Indicates that the following lines are a list of carrier types.
COST_FACTOR		Indicates that the following lines are a list of carrier types and their associated cost factor.

Field	Data Type	Description
Absolute Area	FLOAT	Absolute affected area in km^2
Percent area	FLOAT	Percent affected area
Absolute Traffic	FLOAT	Absolute affected traffic in mE
Percent Traffic	FLOAT	Percent affected area

Field	Data Type	Description
Min_Chan_Spacing_Site	FLOAT	Site
MIn_Chan_Spacing_Cell	FLOAT	Cell
Min_Chan_Spacing_Neighbour	FLOAT	Neighbor Sites
Min_Chan_Spacing_Neighbour2	FLOAT	2^{nd} Order Neighbors
CELL	CHAR	Site Identity
CELL COST_FACTOR	FLOAT	Indicates that the following line contains a cost factor for CELL
GLOBAL ILLEGAL LINES	FLOAT	Indicates that the following line contains a list of channels that may not be used anywhere on the network
SEPARATIONS	CHAR	Indicates that the following lines are a list of cells and separations for the preceding CELL (*means the separation overrides all others)

Field	Data Type	Description
ILLEGAL CHANNELS	CHAR	Indicates that the following line is a space separated list of illegal channels for the preceding CELL.
BORDER RESTRICTIONS	CHAR	Indicates that the following line is a space separated list of country borders whose channel restrictions

4.4 GSM Neighbors

TEMS CellPlanner can import and export to EET/R2C/Planet 2.7 GSM neighbor files. A neighbor file is a simple ASCII space-separated text format and consists of five distinct sections:

- Threshold
- Cell
- Neighbor
- Add
- Delete

The following tables describe the formats of these sections in the files.

Field	Data Type	Description
THRESHOLDS	INT	Four integer fields representing Max Neighbors, Min Neighbors, Min Border Squares and Min Border Percent respectively.
CELL	CHAR	"CELL" indicates that the Site ID following is the serving cell.
Site ID	CHAR	Unique identifier for the site
Sector (cell)	INT	Sector number
BSIC	INT	Not used
BCCH	INT	Not used
HO RxLev	INT	Not used
Number of Neighbors	INT	Number of neighbors following in the file

Field	Data Type	Description
NBR	CHAR	"NBR" indicates that the Site ID is the neighbor of the last serving cell.
Site ID	CHAR	Unique identifier for the site
Sector (cell)	INT	Sector number
HO Margin	INT	Handover Margin
HO RxLev Min	Min	The minimum handover receiver level
Max Distance	INT	Not Used
RxQual	INT	Not Used

Field	Description
Added	Lists cells added manually to the neighbor list. Other fields as previously described.
Deleted	Lists cells deleted manually to the neighbor list. Other fields as previously described.

A sample, truncated, file follows:

```
THRESHOLDS 10 3 10 5
CELL XY001 1 0 0 0 3
NBR XY001 3 0 -120 100000 0
NBR XY001b 1 0 -120 100000 0
NBR XY011 2 0 -120 100000 0
CELL XY001 2 0 0 0 3
NBR XY001b 2 0 -120 100000 0
NBR XY011 2 0 -120 100000 0
NBR XY006c 2 0 -120 100000 0
ADDED
CELL XY001 1 0 0 0 2
NBR XY002 2 0 -120 100000 0
NBR XY002c 2 0 -120 100000 0
CELL XY001 2 0 0 0 1
NBR XY001b 1 0 -120 100000 0
DELETED
CELL XY019 1 0 0 0 7
NBR XY017h 1 0 -120 100000 0
NBR XY019h 1 0 -120 100000 0
NBR XY019h 2 0 -120 100000 0
NBR XY019h 3 0 -120 100000 0
NBR XY036 1 0 -120 100000 0
```

```
NBR XY036 2 0 -120 100000 0
NBR XY036 3 0 -120 100000 0
```

4.5 Site Database

TEMS CellPlanner can import and export the EET/R2C/Planet 2.7 simple text site database file format. The specification of this type of file is as follows.

4.5.1 Header Records

Each site database file has one of each of the records shown in the following table:

Field	Data Type	Description
Version Identifier	CHAR ()	Identifies the version of EET that was used to store the database. For version 2.7 this is "V2.7"
Optional Message	CHAR()	The time and date that the database was last stored
Site format	CHAR()	ERP or EiRP

4.5.2 Sector Data Record Format

This type of record is not used, but it must exist in the file.

4.5.3 Cell Data Record Format

This type of record is not used, but it must exist in the file.

4.5.4 Data Records

Site Data Record

The site database file has one site data record per site. The following table describes the fields in a site data record.

Field	Data Type	Description
Keyword	CHAR (4)	"SITE" identifies the record
Site ID	CHAR (11)	Unique identifier for the site
Easting/ Longitude	FLOAT	The x_coordinate of the site (meters or decimal degrees)

Field	Data Type	Description
Northing/ Latitude	FLOAT	The y-coordinate of the site (meters or decimal degrees)
Site Status Flags	INT(5)	Numeric representation of the site status flags
Ground Height	FLOAT	The height of the site above mean sea level (meters)
Hexagon Flag	INT	Numeric representation of the hexagon radius and type.
Site Type Flag	INT	A decimal number of up to three digits that has the site type and number of sectors encoded into it, as follows: • --N=Number of Sectors (N in range 1 - 6) • -0- = Macrocell • -3- = Microcell • 1--= Repeater Site
Site Name	CHAR (23)	Optional string that can contain anything (including spaces)
Site Name 2	CHAR (23)	Optional string that can contain anything (including spaces)
Narrative	CHAR (80)	Optional string that can contain anything (including spaces)

Sector Data Record

A site database file has one sector data record per sector of every site. The following table describes the fields of a sector data record.

Field	Data Type	Description
Keyword	CHAR(6)	"SECTOR" identifies this record
Alignment	FLOAT	Angle from North of sector (degrees)
Power	FLOAT	ERP or EiRP of sector (dBm) depending on the value of the Site Format field in the Header Record. All power values should be consistent (all ERP or all EiRP)
Tilt	FLOAT	Downtilt of sector (degrees)
Antenna Name	CHAR(99)	Name of antenna (no spaces allowed)
Antenna Height	FLOAT	Height of antenna above ground (meters)
Model Name	CHAR (31)	Name of propagation model (no spaces allowed)

Cell Data Record

A site database file has one cell data record per sector of every site. The following table describes the fields of a cell data record.

Field	Data Type	Description
Keyword	CHAR(8)	"CELLINFO" identifies the start of the cell information details
Equipment Type	CHAR(21)	The equipment type the cell uses
Balanced mobile	CHAR (21)	Mobile / CE type the cell is presently balanced for. If the cell is not balanced then defaults to non-balanced
Equipment Loss	FLOAT	Sum of all the downlink losses / +gains from the presently selected cell equipment
Output Power	FLOAT	Do not change from zero
Uplink Feeder Loss	FLOAT	The feeder loss applicable to the uplink side
Downlink Feeder Loss	FLOAT	The feeder loss applicable to the downlink side
Diversity Gain	FLOAT	The amount of diversity gain from the cell, if applicable
Uplink Misc Loss	FLOAT	The amount of miscellaneous losses on the uplink side.
Downlink Misc Loss Mobile ERP	FLOAT	The peak power of the mobile/CE type for which the cell is balanced.
GSM Range	FLOAT	A user definable range applicable only to GSM systems. Interference in this cell from two other servers is not considered, because the cell cannot cover beyond this range. However, the cell will still interfere in other cells independent of the range.

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